L H Moon
& Son
Bookbinders

NATIONAL MUSEUM
VICTORIA

Museum Victoria
71405

PAPERS AND PROCEEDINGS OF

The Royal Society of Tasmania

Edited by M. R. Banks and Published by the Society

Hobart, Tasmania

July 1979

Volume 113

NATIONAL MUSEUM
- 4 SEP 1979
OF VICTORIA

T. J. Hughes, Government Printer

ISSN — 0080-4703

COUNCIL AND OFFICE BEARERS

Patron

Her Majesty the Queen

President

His Excellency the Governor of Tasmania
Sir Stanley Burbury

Vice-Presidents

Mr G.E.A. Hale
Dr E.A. Colhoun

Council

Mr R.J. Downie
Mr P.S. Manchester
Mr A.R. Neilson
Mr E.H. Norton
Mr K.E.J. Robinson
Mr J.D. Thomson
Mr S.J. Thrower
Mr P.G. Webb

Honorary Secretary

Mr D.R. Gregg

Honorary Treasurer

Mr T.A.H. Knight

Honorary Auditor

Mr D.B. Churchill

Honorary Editor

Dr M.R. Banks

PAPERS AND PROCEEDINGS OF THE ROYAL SOCIETY OF TASMANIA

VOLUME 113

CONTENTS

NATIONAL MUSEUM
- 4 SEP 1979
OF VICTORIA

Page

Annual Report and Balance Sheet v

NUNEZ, M. — A note on the annual variability of solar radiation at Hobart Airport, Tasmania. 1

BAILLIE, Peter — Stratigraphic relationships of Late Ordovician to Early Devonian rocks in the Huntley Quadrangle, south-western Tasmania. 5

TURNER, N.J. — The boundary relationship of the Concert Schist and the Oonah Quartzite and Slate correlate at Dundas. 15

KENNY, Ron — Breathing and heart rates of the southern elephant seal, *Mirounga leonina* (L.). 21

McKENZIE, K.G. — *Tasmanocypris*, a new marine ostracode genus: and a review of the family Paracyprididae (Crustacea; Ostracoda). 29

GOEDE, A. and MURRAY, P. — Late Pleistocene bone deposits from a cave in the Florentine Valley, Tasmania. 39

HICKMAN, V.V. — Some Tasmanian spiders of the families Oonopidae, Anapidae and Mysmenidae. 53

STOCKTON, Jim and WALLACE, Alan — Towards a human prehistory in the lower Derwent River area, south-eastern Tasmania, Australia. 81

FRIEND, J.A. — Two new terrestrial species of *Talitrus* (Amphipoda: Talitridae) from Tasmania. 85

SCOTT, E.O.G. — Observations on some Tasmanian fishes : Part XXV. 99

WALLACE, Alan and STOCKTON, Jim — Skeletal remains at Coningham, Tasmania, Australia. 149

BOLT, Frank — "Female settler Martha Hayes" 1786-1871. 155

LAST, P.R. — A new species of stingray (F. Dasyatidae) with a key to the Australian species. 169

RICHARDSON, L.R. — *Anphilaemon kingi* gen. et sp. nov., a land-leech on King Island, Bass Strait (Haemadipsoidae: Domanibdellidae). 177

BANKS, Maxwell R. — A Permian fault in north-western Tasmania. 185

ROYAL SOCIETY OF TASMANIA

ANNUAL REPORT FOR THE YEAR 1978

The Council has the honour to present to members the following report on the activities of the Society during the year.

COUNCIL AND OFFICE BEARERS

Patron

Her Majesty the Queen

President

His Excellency the Governor of Tasmania
Sir Stanley Burbury

Vice-Presidents

Mr G.E.A. Hale
Dr E.A. Colhoun

Council

Mr R.J. Downie
Mr P.S. Manchester
Mr A.R. Neilson
Mr E.H. Norton
Mr K.E.J. Robinson
Mr J.D. Thomson
Mr S.J. Thrower
Mr P.G. Webb

Honorary Secretary

Mr D.R. Gregg

Honorary Treasurer

Mr T.A.H. Knight

Honorary Auditor

Mr D.B. Churchill

Honorary Editor

Dr M.R. Banks

PRESIDENT

Sir Stanley Burbury took the Chair, as President of the Society, at the Annual General Meeting in March and at the June General Meeting. He also took the Chair at the Annual General Meeting of the Northern Branch in March.

ROYAL SOCIETY OF TASMANIA MEDAL

At the General Meeting in June, the President presented the Royal Society of Tasmania Medal to Dr M.R. Banks in recognition of prolonged research of high merit.

Previous recipients of the medal have been:

1976	Donald Martin
1970	D.L. Serventy
1940	W.E.L. Crowther and V.V. Hickman
1935	A.N. Lewis
1934	H.H. Scott
1930	Clive Lord
1927	L. Rodway

HONORARY LIFE MEMBER

Mr. T.E. Burns was elected an Honorary Life Member in recognition of the outstanding service he has given to the Society particularly to the Northern Branch.

ANNUAL MEETING

At the Annual Meeting on 7 March, Mr K.E.J. Robinson retired as Vice-President, and Dr E.A. Colhoun and Mr K.D. Nicolls as Members of the Council. The following were elected -

Vice President	-	Dr E.A. Colhoun
Members of Council	-	Mr E.H. Norton
	-	Mr K.E.J. Robinson
Honorary Secretary	-	Mr D.R. Gregg
Honorary Treasurer	-	Mr T.A.H. Knight
Honorary Auditor	-	Mr D.B. Churchill

LECTURES

The following lectures were given at General Meetings during the year -

March	'Biological Survey in Australia'	Dr W.D.L. Ride, CSIRO, Canberra
April	'China - an Ancient Culture, a Recent Perspective'	Mr H.S. Payne, TCAE, Launceston
May	'Supplying Tasmania's Future Energy Needs'	Mr J.R. Ashton, H.E.C.
June	'Readings from a Page of Earth History - Permian in Tasmania'	Dr M.R. Banks, University of Tasmania
July	'Land, a Diminishing Human Resource'	Dr D.F. Smith, TCAE, Launceston
August	'The Nature of Bush Logic'	Professor G.W. Boyd, University of Tasmania
September	'The Future of Private Forestry in Tasmania'	Mr P.T. Unwin, Forestry Commission
October	'Fossil Vertebrates from Antarctica'	Mr N.R. Kemp, Tasmanian Museum
November	'Tasmania's Rural Industry - the past, present and future'	Mr P.J. Fountain, Department of Agriculture

LIBRARY

Mrs D.A. Lewis, Librarian, reports on the year's activities:

The re-organisation of the library has proceeded steadily in 1978. The exchange programme has been reviewed, a new system of exchange records developed and addresses of our exchange partners up-dated. As well, a review of titles sent to us on exchange has been carried out. Work on this project is now almost complete with respect to non-English speaking partners and the remainder will be completed in 1979. The contact made with our partners in the course of this operation has resulted in the resuscitation of some languishing exchanges, and in the arrival of some titles not previously sent to us.

On the other hand, a few of our partners have complained that there is an imbalance in the exchange arrangements in that they send multiple titles and receive

only our annual *Papers and Proceedings*, and it seems likely that some partners may feel that they must prune their donations in the near future. However, it speaks well for the prestige of our *Papers and Proceedings* that it is so widely accepted. Indeed, we receive about two titles for every copy of our publication that we send away. This year 67 copies of Volume 112 were sent to Australian partners and another 256 to overseas partners in 48 countries.

A more efficient system for accessioning periodicals has been installed and titles checked for accuracy.

A card system has been set up for recording *Papers and Proceedings* sent to members so that confusion should be minimized.

The major re-organisation has been in the re-shelving of serials in alphabetical order by title as at time of publication. This procedure was decided upon after considerable investigation and the work is now well advanced. While it has been going on, there has been some slight inconvenience but the general consensus is that the new arrangement will be a considerable improvement in providing speedy service to our readers.

The binding programme has suffered somewhat because of staff cuts within the University Library and only 710 volumes have been bound this year, though many hundreds more have been prepared for binding as soon as possible. It may be some years before they can all be done, but while they are tied, labelled and in order, deterioration will be minimized.

During the year 167 visits by members of the Society have been recorded in the Register of Users. Including University staff and other visitors, some from overseas, the total number for the year was 492.

Inter-library loan requests have come from as far afield as New Zealand and Papua New Guinea. Total inter-library loans, or photo-copies, supplied have been 189.

PUBLICATIONS

A bumper volume, 356 pages, was published as Volume 112 of the *Papers and Proceedings* in August, 1978. The processing of manuscripts for publication was considerably eased by the use of the efficient typing services of Mrs Margaret Martyn by arrangement with Professor D.H. Green, University of Tasmania.

At the end of 1978, 6 papers totalling 55 pages had been prepared for publication as part of Volume 113.

The Society is once more indebted to Dr Banks for his continuing work as Honorary Editor.

FINANCES

The cost of producing the *Papers and Proceedings* has continued to rise and put publication into jeopardy in spite of the recent increase in subscriptions to members. The Council welcomes an increase in the Tasmanian Government grant for publications from $1 400 to $3 000 and an increase in the University of Tasmania grant from $1 000 to $1 500.

MEMBERSHIP

During the year the membership was 503, a decrease of 29.

The membership is made up as follows -

	Northern Branch	Total
Honorary Life Members	3	6
Life Members	9	38
Ordinary Members, receiving *Papers and Proceedings*	70	258
Ordinary Members, not receiving the *Papers and Proceedings*	103	175
Associate Members	17	26
	202	503

COUNCIL MEETINGS

The Council met four times during the year with Mr P.S. Manchester and Mr P.G. Webb representing the Northern Branch on the Council.

REVIEW OF RULES

The Council set up a committee to carry out an overall review of the Society's function and to make recommendations to the Council on possible changes to the Rules.

NOMINEES TO OTHER BODIES

The Council re-elected Dr M.R. Banks and Dr D. Martin to the Board of Trustees of the Tasmanian Museum and Art Gallery. They report on the year's activities:

> All the buildings purchased by the State from the Commonwealth in 1977 have been made available to the Tasmanian Museum with the exception of the temporary weather-board building on the corner of Dunn and Macquarie Streets. Funds have been provided by the Tasmanian Government for the renovation of the building at 40 Macquarie Street formerly housing the Commonwealth Department of Transport. This building, part of the original Commissariat Stores, dates back to 1808 and is almost certainly the oldest surviving building in Tasmania. It will be used for offices and working areas and will free useful display space in the present buildings.
>
> Dr A.E. Orchard took up duties as Curator of the Tasmanian Herbarium in March. Substantial collections have been donated to the Herbarium, including about 18 000 lichens, collected by the late Dr G.C. Bratt, and the herbarium of Dr Winifred Curtis.
>
> Mr N.R. Kemp, Curator of Geology, spent part of the 1977-78 summer with an American expedition collecting Triassic fossil vertebrates in the Cumulus Hills, Antarctica.
>
> A grant of $20 000 from the Utah Foundation, enabled the purchase of a painting 'Tivoli' by John Glover.
>
> Dr Banks was elected Chairman of the Trustees at the beginning of 1978.

Mr M.H. Hurburgh retired after serving as the Council's nominee on the Board of Trustees of the Royal Tasmanian Botanical Gardens since 1972 and was replaced by Dr Jocelyn E.S. Townrow. She reports on the year's activities:

> 1978, the Gardens' 160th year, was remarkable for the development of information and educational activities, for the increasing excellence of the spring and summer floral displays in the grounds and the conservatory, and extensive new landscaping in various parts of the gardens.
>
> The State Government Grant for 1978/79 is $460 000 which, although a further increase of $40 000 on last year, will not permit any major capital work to be undertaken nor replacement of a senior gardener.
>
> Mr Hurburgh was appointed Education and Information Officer in February and the Information Centre is now firmly established.
>
> The rise of approximately 10% in numbers of visitors to the Gardens over the past 6 months (12 - 16 000 per month) compared with 1977 reflects increasing public interest in the Gardens and there has been considerable growth in inquiries.
>
> Projects in hand include the establishment of a Gardens Museum to be housed in the Superintendent's Cottage, the development and display of a newly discovered Aboriginal midden in association with an endemic and native flora area at the northern end of the Gardens, and the planning of a "blind walk" near the Lily Pond which will be an educational experience for sighted (blindfolded) as well as blind visitors.

NORTHERN BRANCH

The Northern Branch of the Society based in Launceston elected the following Council -

Chairman	-	Mr H.S. Payne
Vice-Chairman	-	Dr D.F. Smith
Honorary Secretary	-	Mr P.G. Webb
Honorary Treasurer	-	Mr J.D. Abey
Honorary Auditor	-	Mr H.C.A. Pitt
Members	-	Miss J.S. Gardner (elected in 1977)
	-	Mr P.S. Manchester (elected in 1977)
	-	Mr P.J.F. Leonard
	-	Mr D. Walter
	-	Mrs N.I. Hardy Wilson

Dr E.V.R. Ratcliff and Mr K.E.J. Robinson were co-opted to the Council.

The following lectures were given:

March	'The Royal Society: its Past and Future'	Mr P.G. Webb
April	'Is there a Future in the Search for New Drugs?'	Professor R.H. Thorpe
May	'Incompatibility in Plants'	Dr David Hamilton
June	'Telecom, Australia Post, the H.E.C. - their Prices and their Profits'	Dr J.Y. Henderson
July	'What do we want from our School Teachers?'	Dr Geoffrey Haward

August	'Social Problems in Launceston'	Mr Peter Hanson
September	'Health Problems of Industrial Societies'	Dr John Powles
October	'The Greek Arrival in Tasmanian Architecture'	Dr E.V.R. Ratcliff
November	'Origins of and Administration of the Legal System in Tasmania'	Mr J.R. Rex
December	Members Night -	
	'Some Colonial Correspondence'	Mrs P. Ratcliff
	'Some Interesting Features of Early Tasmanian Architecture'	Mr A.T. Orr
	'Launceston's Sister City in Malaysia'	Mr H.S. Payne
	'Readings appropriate to Christmas'	Mr R.E. Ward

The four lectures from May to August were a second series by staff of the Newnham Campus of the Tasmanian College of Advanced Education.

Excursions visited the Launceston Gas Works in March and the Launceston law courts in November.

ACKNOWLEDGEMENTS

The Council is grateful for help generously given by many individuals and organisations. In particular, the lecturers, the Government of Tasmania, the University of Tasmania, the Tasmanian Museum and Art Gallery, and the Queen Victoria Museum and Art Gallery are specially thanked for their help and co-operation.

ROYAL SOCIETY OF TASMANIA

Balance Sheet as at 31 December 1978

1977			1978	1977		1978
93 809.07	Accumulated Funds		60 676.30	33.00	Cash on hand	33.00
94.00	Subscriptions in advance		36.00		Cash at bank -	
	Trust Funds -			3 267.85	General Account	1 103.65
1 252.87	Clive Lord Memorial Fund	1 273.09		337.16	Papers and Proceedings Account	1 402.40
1 880.39	A.N. Lewis Memorial Fund	2 007.97		542.37	Clive Lord Memorial Fund	803.99
814.52	Morton Allport Memorial Fund	869.83		780.39	A.N. Lewis Memorial Fund	907.97
351.27	A.A. Clark Bequest	371.27		860.00	Mortgage Loan	860.00
2 361.97	Joseph Milligan Bequest	2 494.39			Commonwealth Treasury Bond and	
1 223.30	R.M. Johnston Memorial Fund	1 276.23		10 430.00	Inscribed Stock (at cost)	9 840.00
522.69	Henry Oliver Bequest	552.89		7 000.00	Interest Bearing Deposits	7 000.00
1 322.17	W.H. Hudspeth Memorial Fund	1 379.57		15 000.00	Library (at valuation for insurance)	15 000.00
1 376.67	Life Membership Fund	1 477.07	11 702.31	66 758.15	Publications (at selling prices)	35 463.60
$105 008.92			$72 414.61	$105 008.92		$72 414.61

In my opinion the attached Balance Sheet, Accumulation Account and Statements of Receipts and Payments for the General Account and Papers and Proceedings, are properly drawn up so as to give a true and fair view of the state of affairs of the Royal Society of Tasmania as at 31 December 1978, according to the books and records produced to me. The asset values of the Library and Publications on hand is accepted at the valuation as stated in the Balance Sheet, having been submitted to me by the Royal Society of Tasmania.

16 February 1979

D.B. Churchill, F.A.S.A.
Licensed Auditor

ROYAL SOCIETY OF TASMANIA

GENERAL ACCOUNT TO 31 DECEMBER 1978

Receipts			Payments	
Balance brought forward		3 267.85	Stationery	100.57
Subscriptions -			Insurance	182.22
2 @ $200	400.00		Attendants' fees	369.11
218 @ $ 12	2 615.29		Library expenses	253.00
159 @ $ 8	1 270.00		Presentations	197.01
23 @ $ 5	115.00		Secretarial fees	200.00
Other years	266.02	4 666.31	Northern Branch	1 146.00
Interest		1 126.96	Petty cash	90.00
Sales of publications & Papers and Proceedings		1 604.40	Management fee, University	1 450.00
Government Grant		1 450.00	Post box rental	102.00
Rent		103.45	Postage and freight	1 165.05
Miscellaneous		108.24	Investments	10.00
University subsidy		1 250.00	Photocopying	86.67
			Symposium expenses	(10.00)
			Subscriptions	509.73
			Printing of Papers & Proceedings & publications	6 622.20
				12 473.56
			Balance carried forward	1 103.65
		$13 577.21		$13 577.21

PAPERS AND PROCEEDINGS ACCOUNT TO 31 DECEMBER 1978

Receipts		Payments	
Balance brought forward	337.16	Telephone and sundry expenses	13.40
Interest	678.64		
Redeemed investment	400.00		
			13.40
		Balance brought forward	1 402.40
	$1 415.80		$1 415.80

Papers and Proceedings of the Royal Society of Tasmania, Volume 113, 1979.

(ms. received 28.7.1978)

A NOTE ON THE ANNUAL VARIABILITY OF SOLAR RADIATION AT HOBART AIRPORT, TASMANIA

by M. Nunez
University of Tasmania

(with one table and one text figure)

NATIONAL MUSEUM
- 4 SEP 1979
OF VICTORIA

ABSTRACT

NUNEZ, M., 1979 (20 vii): A note on the annual variability of solar radiation at Hobart Airport, Tasmania. *Pap. Proc. R. Soc. Tasm.*, 113: 1-3. ISSN 0080-4703. Department of Geography, University of Tasmania, Hobart, Tasmania, Australia.

The annual variability of solar radiation at Hobart airport is calculated. The implication of this variability for the solar energy potential of Tasmania is discussed.

There is at present an increasing awareness of the potential for the use of solar energy in domestic and industrial application. An important facet in any practical use of solar energy is the day to day variability of the incoming solar radiation. This factor has largely been ignored in geographical assessments of solar radiation as they mostly deal with climatological monthly averages (Hounam 1963; Paltridge and Proctor 1976).

To illustrate the magnitude of the variability, ten years of daily solar radiation data (1968-1977) collected over Hobart airport were used in this analysis. The data was obtained from the Australian Bureau of Meteorology which maintains a network of solar energy monitoring stations throughout Australia. The data was collected by a pyranometer. At any one instant of time the instrument produces a millivolt signal proportional to all direct and diffuse solar energy incident on a unit horizontal surface per unit time (Robinson 1966). Integrating the signal over a day yields the daily flux which is commonly expressed in units of Mega-Joules per metre^2 per day ($MJm^{-2}day^{-1}$).

Cloudless conditions were investigated first since solar radiation under these conditions would represent a convenient upper boundary to the energy received at the surface. Inspection of these days gave a smooth curve for the daily distribution of solar radiation over the year (fig. 1). All data were then analyzed by grouping together daily totals of solar radiation for each day of the year with its counterparts. The mean and standard deviation were then calculated for each group and are shown in figure 1. A ten day running mean through both data sets shows a maximum standard deviation in early January which exceeds 6 $MJm^{-2}day^{-1}$ or 28% of the incoming solar radiation. This value decreases with solar elevation reaching a minimum of 1.6 MJm^{-2} day^{-1} in late June which represents approximately 35% of the incoming radiation.

The daily variability is dominantly a function of cloud cover, and to a lesser extent will depend on atmospheric water vapour and dust content (Davies *et al.* 1975). Therefore it is possible to represent the cloudless solar radiation as a smooth curve which is usually within 5% of the observed daily values. On the other hand solar radiation depletion by clouds can be extremely variable since it depends on such cloud properties as type, amount, thickness, liquid water and water vapour content, etc.

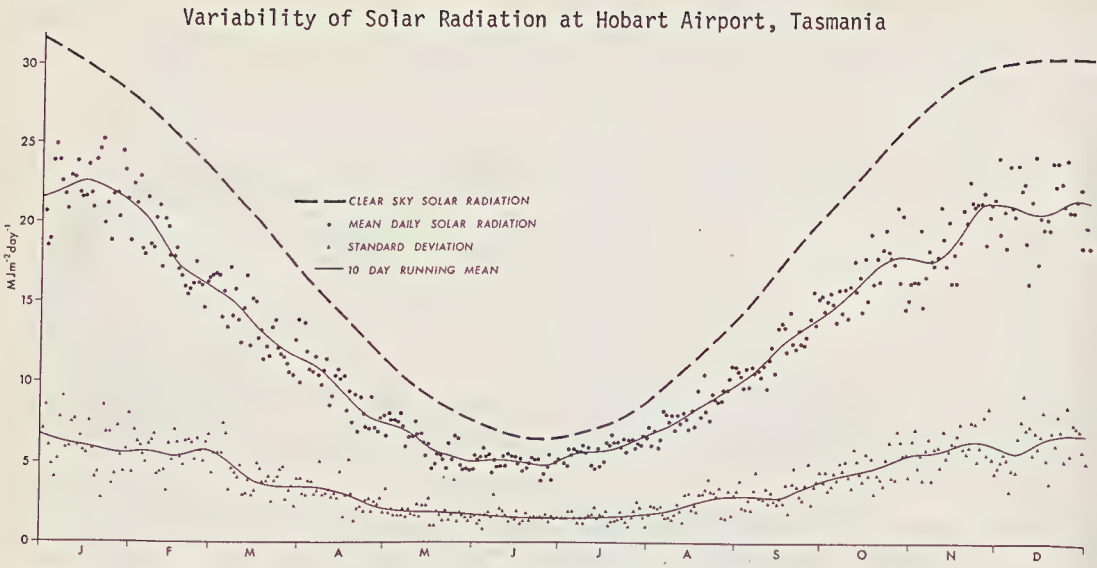


FIG. 1.- Daily solar radiation statistics for Hobart Airport (1968-1977).

It is evident from the above results that the magnitude of the solar radiation variability imposes doubts on the usefulness of monthly average data in solar energy applications. More relevant information can be obtained from a frequency distribution of the solar energy received. Table 1 gives the average number of days in a month with energy fluxes along selected intervals. The intervals are in units of 25% of the mean monthly solar radiation (K_c). Results show that there is a maximum of 8.4 days in May and a minimum of 6.0 days in January and October when the solar energy is less than $\frac{3}{4}$ of the mean monthly value. Clearly the above represent significant portions of the month which are considerably below the monthly average figure. Perhaps it would be more useful to define a "working" value of solar radiation which would be lower than 90% of the daily values in a given month (the ten percentile value). Inspection of Table 1 shows that $\frac{1}{2}$ of the mean monthly radiation K_c could be considered as a ten percentile value in eleven months, although it is marginal for the month of March.

In some cases, a solar energy storage system will respond not only to daily events but to processes that occurred in the past as well. This kind of storage system would minimize the problem of collecting little energy on an overcast day in a solar climate which is highly variable on a daily basis. Unfortunately this does not seem to be the case for Hobart airport since running a two day moving average on the data does not cause large changes in the number of days in the low end of the energy spectrum. On average, the number of days with energy less than $\frac{3}{4}$ of K_c decreases only by 1 to 2 days for most months. A likely explanation for this effect is the persistence that exists in the weather systems which deplete solar radiation.

It should be kept in mind that the above data analysis refers to one location and that serious errors could arise if the results are applied elsewhere. This is particularly relevant in the Tasmanian context where climatic gradients are large and daily solar radiation variability could change significantly throughout the island. For example, two stations may have the same mean solar radiation but different frequency distribution in their solar energy receipt. A west coast location may be marked by sharp changes in daily cloud cover (clear to overcast) with a marked persistence in each state, while an east coast location may exhibit a more even cloud cover regime. It is evident that solar energy storage would be a much more serious problem in the west coast.

TABLE 1

FREQUENCY DISTRIBUTION OF SOLAR ENERGY FOR HOBART AIRPORT (1968-1977)

(N refers to the average number of days in a month with a given energy interval. Energy intervals are expressed as per cent of the mean monthly value K_c)

	J	F	M	A	M	J	J	A	S	O	N	D
Daily solar radiation (cloudless), $MJm^{-2}day^{-1}$	30.0	25.4	20.2	14.1	9.3	6.5	7.6	11.6	18.2	24.7	29.4	30.8
Daily solar radiation K_c (all days), $MJm^{-2}day^{-1}$	22.0	18.1	13.6	9.3	6.1	5.0	5.8	8.2	12.2	16.5	19.3	21.0
$0 \leq K_i < 0.25\ K_c$, N:	0.5	0.7	0.7	0.5	0.1	0.3	0.4	0.8	0.1	0.3	0.5	0.7
$0.25\ K_c \leq K_i < 0.50\ K_c$, N:	1.7	2.3	2.4	2.4	2.2	1.8	2.3	1.7	1.6	2.1	2.8	1.7
$0.50\ K_c \leq K_i < 0.75\ K_c$, N:	3.8	3.9	3.9	4.7	6.1	5.9	4.1	5.5	4.3	3.6	3.8	4.8
$0.75\ K_c \leq K_i < 1.00\ K_c$, N:	6.6	4.6	7.3	7.3	7.5	6.3	8.3	7.0	8.8	8.0	6.6	6.6
$1.00\ K_c \leq K_i < 1.25\ K_c$, N:	10.7	8.2	9.3	7.5	7.2	7.6	10.3	9.0	9.4	9.6	8.4	10.1
$1.25\ K_c \leq K_i < 1.50\ K_c$, N:	7.7	7.8	5.2	5.2	5.6	7.5	4.4	5.2	4.3	6.1	6.4	6.4
$1.50\ K_c \leq K_i < 1.75\ K_c$, N:	0	0.5	2.2	2.3	2.0	0.3	1.0	1.7	1.5	1.1	1.4	0.7
$1.75\ K_c \leq K_i < 2.00\ K_c$, N:	0	0	0	0.1	0.3	0.3	0.2	0.1	0	0.2	0.1	0

The above example is only speculative since no monitoring network of solar radiation exists in the state. In fact Hobart airport is the only station in Tasmania where solar data is collected by the Bureau of Meteorology. The establishment of such a network would represent a first step in the assessment of the solar energy potential for the state.

ACKNOWLEDGEMENTS

The author gratefully acknowledges the cooperation of the Australian Bureau of Meteorology who supplied the data. Thanks are also due to Mrs. K. Morris who did the drawing and Miss T. Flannagan who typed the manuscript.

REFERENCES

Hounam, C.E., 1963: Estimates of solar radiation over Australia. *Australian Meteorological Magazine*, 43: 1-14.

Davies, J.A., Schertzer, W. and Nunez, M., 1975: Estimating global solar radiation. *Boundary Layer Meteorology*, 9: 33-52.

Paltridge, G.W. and Proctor, D., 1976: Monthly mean solar radiation statistics for Australia. *Solar Energy*, 18(3): 235-243.

Robinson, G.D., 1966: SOLAR RADIATION. Elsevier, 347 pp.

Papers and Proceedings of the Royal Society of Tasmania, Volume 113, 1979

(ms. received 4.12.1978)

STRATIGRAPHIC RELATIONSHIPS OF LATE ORDOVICIAN TO EARLY DEVONIAN ROCKS IN THE HUNTLEY QUADRANGLE, SOUTH-WESTERN TASMANIA

by Peter Baillie
Geological Survey of Tasmania

(with three text figures and four plates)

ABSTRACT

BAILLIE, P., 1979 (20 vii): Stratigraphic relationships of Late Ordovician to Early Devonian rocks in the Huntley Quadrangle, south-western Tasmania. *Pap. Proc. R. Soc. Tasm.*, 113: 5-13 (incl. four plates). ISSN 0080-4703. Geological Survey of Tasmania, Department of Mines, Hobart, Tasmania, Australia.

During mapping of the Huntley Quadrangle in south-western Tasmania, two new, important, graptolite-trilobite-brachiopod bearing sequences were found in the upper part of the Lower Palaeozoic succession. The stratigraphy of these sequences is described. To avoid confusion a new group and a new formation, which includes the Westfield Beds (*sensu* Corbett and Banks 1974), are proposed.

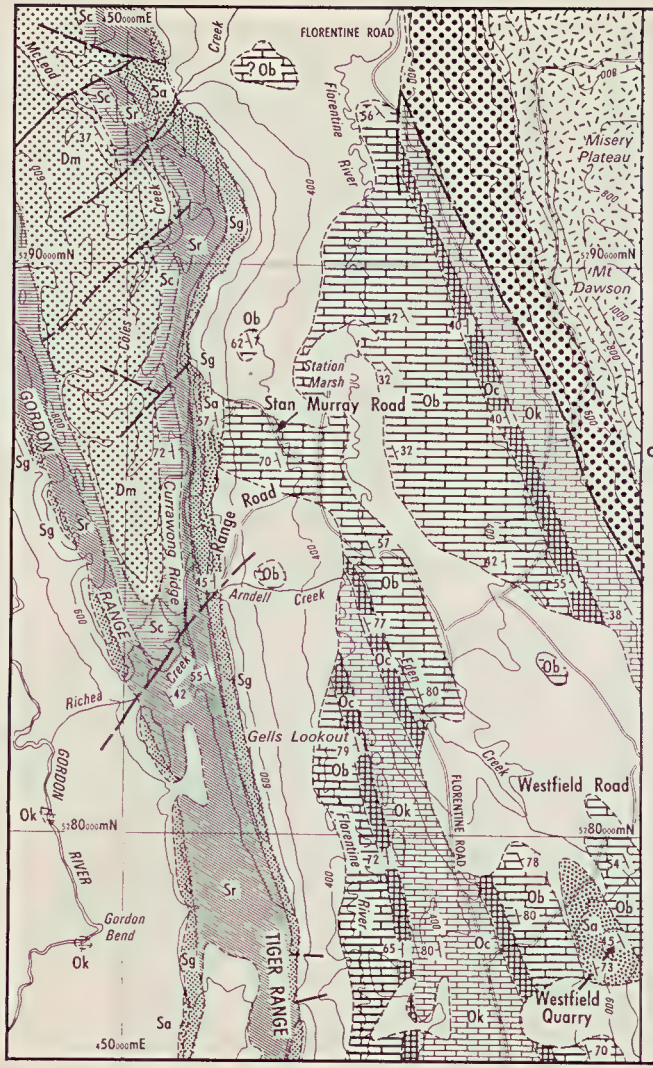
INTRODUCTION

Geological studies of the Florentine Valley prior to that of Corbett and Banks (1974) are summarised in that paper. The Westfield Beds were defined therein as "that unit of buff-coloured siltstone and fine sandstone with some sandstone ..... The base of the unit has not been seen and its upper contact with the Eldon Group is not yet clearly defined." In diagrams, and inferentially throughout the text, the Westfield Beds were used by Corbett and Banks *(op. cit)* as a lithostratigraphic unit quite distinct from, yet directly overlying the main limestone sequences of the Gordon Subgroup. Their separation from the overlying Eldon Group correlate was based not so much on lithological grounds, as a desire to characterise an Ordovician clastic sequence as distinct from a Silurian one.

Corbett and Banks (1975) redefined the Gordon Subgroup so as to include the Westfield Beds, but gave no criteria for recognising the top of the Westfield Beds or the base of the Eldon Group correlate.

The section described by Corbett and Banks in 1974, that is, the Westfield Road section, has weathered and deteriorated extremely rapidly. Nevertheless, the section must even then have been poorly exposed and unsatisfactory. In marked contrast, new sections at Westfield Quarry (and in its immediate environs) together with almost wholly exposed sections on Stan Murray Road and Range Road, indicate that the lithologies used to characterise the Westfield Beds by Corbett and Banks (1974) are repetitive and a comparatively minor element in a thick and essentially sandstone sequence.

Because of some confusion it is considered best to propose a new formation based on the excellent sections on Stan Murray Road and Range Road. This new formation spans the Ordovician - Silurian boundary, incorporates the Westfield Beds *sensu* Corbett and Banks (1974), and forms the uppermost unit of the Gordon Subgroup.



SKETCH MAP OF GEOLOGY OF PART OF FLORENTINE VALLEY – TIGER RANGE – GORDON RIVER AREA

0 1 2 3 4 km

Contour interval 100 metres

QUATERNARY		Alluvium, slope deposits, fluvioglacial gravels.
JURASSIC		Dolerite.
TRIASSIC — PERMIAN — CARBONIFEROUS		Parmeener Super – group.
? EARLY DEVONIAN	Dm	McLeod Creek Formation.
SILURIAN	Sc	Currawong Quartzite.
	Sr	Richea Siltstone.
	Sg	Gell Quartzite.
	Sa	Arndell Sandstone.
ORDOVICIAN	Ob	Benjamin Limestone.
	Oc	Cashions Creek Limestone.
	Ok	Karmberg Limestone.

TIGER RANGE GROUP

GORDON SUBGROUP

70 Strike and dip of bedding.

Probable fault.

Geological boundary – approximate.

FIGURE 1

STRATIGRAPHIC RELATIONSHIPS

Details of the distribution of the formations is shown in figure 1. The stratigraphic succession in the Tiger Range area may be summarised as follows (thicknesses estimated):-

Tiger Range Group	McLeod Creek Formation	400+m
	Currawong Quartzite	150 m
	Richea Siltstone	220 m
	Gell Quartzite	130 m
Gordon Sub-group	Arndell Sandstone	250 m
	Benjamin Limestone Cashions Creek Limestone Karmberg Limestone	2100 m

Gordon Sub-group

The limestone sequences of the Gordon Sub-group have been described by Corbett and Banks (1974). Only the top formation therefore will be discussed here.

Arndell Sandstone

Definition: This unit of buff-coloured siltstone and very fine-grained sandstone is about 250 m thick and overlies the Benjamin Limestone on both the eastern flanks of the Tiger Range and in the Westfield Quarry area. The formation is named after Arndell Creek [DN525843], a tributary of the Florentine River. The formation includes the Westfield Beds *sensu* Corbett and Banks (1974). The type section is a composite stratotype composed of the Stan Murray Road and Range Road sections.

Description: The base of the formation on Stan Murray Road consists of buff-coloured, micaceous siltstone. Bioturbation is often present. These siltstone layers underlie thinly-bedded, very fine-grained micaceous, quartz sandstone that have a maximum bedding thickness of 100 mm.

On Range Road well-laminated beds of very fine-grained micaceous, quartz sandstone range in thickness from 40 to 400 mm. Siltstone is only a minor part of the sequence. Herringbone-type cross bedding is occasionally present. Other sedimentary structures include scours and dewatering structures. Vertical feeding-burrows are common and other bioturbation structures are often present. Towards the top of the formation there are beds of coarser, quartz sandstone up to 1 metre in thickness.

In the Westfield area the sequence consists of siltstone and fine-grained sandstone with sandstone becoming more common upwards. The top of the formation has been removed by erosion.

Palaeontology: The formation is richly fossiliferous at many horizons (fig. 2). Brachiopods, trilobites, Bryozoa, graptolites and Bivalvia are present in siltstone, and brachiopods and solitary rugose corals are present in the sandstones. *Atavograptus* sp., *Glyptograptus persculptus* (Salter), *Climacograptus normalis* Lapworth and *?Akidograptus* sp., from an horizon at Westfield Quarry, some 150 m above the base of the formation, indicate an Early Llandovery *persculptus* to low *acuminatus* zonal age (Baillie, Banks and Rickards 1978). On Range Road [DN515843] there are bands rich in *Eospirifer* sp. nov., probably the earliest occurrence of strophic spiriferids, (P.M. Sheehan *pers. comm*). Other aspects of the palaeontology of this formation are discussed in Corbett and Banks (1974), Baillie and Clarke (1976), and Baillie *et al.* (1978).

Late Ordovician to Early Devonian Rocks in the Huntley Quadrangle

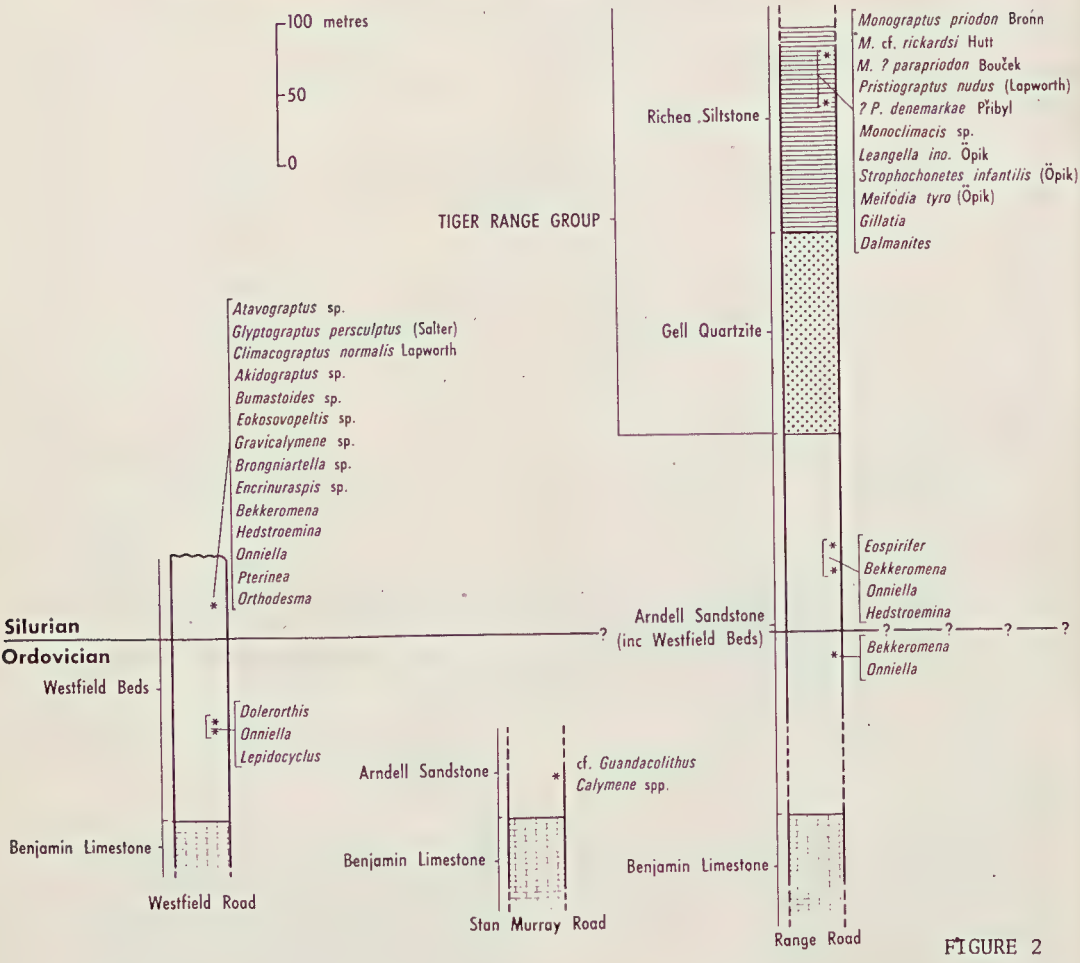


FIGURE 2

Tiger Range Group

The Tiger Range Group is defined as consisting of, in ascending stratigraphic order, the Gell Quartzite, the Richea Siltstone, the Currawong Quartzite and the McLeods Formation. These formations are defined below. The Tiger Range Group has a total thickness in excess of 900 m and ranges in age from Early Silurian to probable Early Devonian. The sequence is of shallow-water marine origin and is a litho-stratigraphic correlate of the Eldon Group of Western Tasmania.

The type area is in the Tiger Range, in the vicinity of Range Road and Coles Creek.

Gell Quartzite

Definition: The formation is composed of the hard grey quartzite forming the prominent topographic ridge along the eastern edge of the Tiger Range. It has a maximum thickness of about 130 m. The type section is exposed on Range Road near the headwaters of Arndell Creek.

Description: The formation consists of beds of hard, grey orthoquartzite ranging in thickness from 20 mm to over 2 m, but usually from 400 - 600 mm.

The rocks are fine to very fine-grained as seen in thin sections (specimens 76-562, 76-563, 76-564 in the Department of Mines collection). The finer grained rocks (specimens 76-562, 563) are moderately to well sorted (So 1.2 - 2.0), and consist of angular to subrounded grains of quartz, rock fragments, plagioclase (albite) and detrital mica. Heavy minerals may be present. The quartz grains are of single crystals which often show undulose extinction resulting from strain. The matrix often contains carbonaceous material. The presence of some strained quartz grains and albite indicates that a metamorphic terrain formed part of the original source area. The fine sandstone (specimen 76-564) is well sorted (So 1.2 - 1.4), and individual grains are more rounded than the grains of the very fine sandstone. The rock is more mature than the very fine-grained sandstone with only occasional rock fragments present.

The tops of the sandstone beds may be scoured and may show oscillation or interference ripples (plate 1). Worm casts may be present on the tops of some ripples (plate 2). The sandstone beds often show internal bioturbation.

Some thin, micaceous and ?carbonaceous mudstone is interbedded with the orthoquartzite but forms only a minor part of the sequence. There is a gradational contact over a short stratigraphic interval between this formation and the overlying Richea Siltstone, with siltstone becoming more common upwards in the sequence.

The presence of oscillation ripples in sandstone probably indicates deposition in shallow water associated with wave action (e.g. Conybeare and Crook 1968). Interference ripples are commonly formed in shallow water, where shallowing of the sea floor, or coastal topography, causes deflections of the wave pattern (Conybeare and Crook 1968).

Richea Siltstone

Definition: That formation of brown and green siltstone lying above the Gell Quartzite and below the Currawong Quartzite. Maximum thickness is of the order of 130 m. It is best exposed in road cuttings on Range Road and the branch of Range Road that follows the western side of Gells Lookout.

Description: The formation consists of a uniform sequence of well-bedded, buff to grey-green, micaceous siltstone. Bioturbation is usually present. Thin, fine-grained sandy layers also occur.

Palaeontology: Tow richly fossiliferous horizons are known. The monograptids present indicate a very late Llandovery age of either the *crenulata* or *griestoniensis* Zones (Baillie 1977). The most common graptolite found is *Monograptus priodon* Bronn , stipes of which are often current oriented (plate 3). Other monograptids include *M. c.f. rickardsi* Hutt, *M.?parapriodon* Bouček, *Pristograptus nudus* (Lapworth), *?P. denemarkae* Přibyl, *Monoclimacis* and a single specimen of either *Cyrtograptus* or *M.tullbergi* Bouček. Figure 3 shows the ranges of graptolites found in this formation. Other fossils found include very well-preserved *Dalmanites* sp., brachiopods including *Leangella ino* Öpik, *Strophochonetes infantilis* (Öpik) *Meifodia tyro* (Öpik), ostracods and rare asterozoans.

Currawong Quartzite

Definition: This formation of hard, white quartzite forms Currawong Ridge [DN509850]. Maximum thickness is of the order of 150 m. The base of the formation is best exposed in road cuttings immediately north of the quarry at the northern end of Currawong Ridge. The top of the formation has been observed only in Coles Creek.

Late Ordovician to Early Devonian Rocks in the Huntley Quadrangle

RANGES OF GRAPTOLITES [after RICKARDS (1976)]
FOUND IN RICHEA SILTSTONE

FIGURE 3

Description: The formation consists of interbedded massive quartzite in beds 300 - 800 mm thick with minor grey laminated micaceous siltstone in beds 40 - 150 mm thick. The sandstone beds are not graded and have sharp tops and bottoms. Thin sections (specimen 78 - 842) of a sandstone shows it to be of extremely well-sorted (So 1.0 - 1.1), very fine-grained quartz with some detrital mica grains. Individual quartz grains are subangular to well-rounded. Some of the sandstone show bioturbation. The siltstone is generally well laminated and may contain authigenic pyrite (specimen 78 - 843).

Like the Gell Quartzite the tops of some of the sandstone beds show well-developed oscillation ripples (plate 4).

Palaeontology: The formation is poorly fossiliferous but *Nucleospira*, *Lissatrypa*, *Leangella*, *Strophochonetes*, *Isorthis*, *?Howellella*, heliolitids, favositids and solitary rugose corals are present. The presence of *Nucleospira* and *Leangella* suggest a Late Silurian age (M.J. Clarke *pers. comm*).

McLeod Creek Formation

Definition: The formation consists of the thinly-bedded, grey micaceous fine-grained sandstone and dark-grey, micaceous mudstone overlying the Currawong Quartzite. It is best exposed in Coles Creek and its tributaries, including McLeod Creek [DN495923]. The thickness is greater than 400 m. The top of the formation has been removed by erosion.

Description: This formation was seen only in Coles Creek where it consists of thinly-bedded, grey, micaceous fine-grained sandstone and siltstone in beds 40 - 200 mm thick. The upper part of the formation consists of well-bedded, dark-grey, micaceous siltstone and mudstone in beds up to 250 mm in thickness.

The formation is unfossiliferous.

ACKNOWLEDGEMENTS

The author gratefully acknowledges the help given in the field by Mr. M.J. Clarke. He also thanks Mr. Clarke for helpful discussion and critical reading of the manuscript. The manuscript was also critically read by Dr. N. Farmer and Dr. E. Williams, Geological Survey of Tasmania. The graptolites were identified by Dr. R.B. Rickards, Sedgwick Museum, University of Cambridge. M.J. Clarke identified the other fossils quoted in the text. The figures were draughted by T.R. Bellis. This paper is published by permission of the Director of Mines, Tasmania.

REFERENCES

Baillie, P.W., 1977: Further comments on Early Palaeozoic (Late Ordovician - Early Silurian) graptolites in the Huntley Quadrangle. *Unpubl. Rep. Dep. Mines Tasm.*, 1977/19.

_____ and Clarke, M.J., 1976: Preliminary comments on Early Palaeozoic (Late Ordovician - Early Silurian) rocks and fossils in the Huntley Quadrangle. *Unpubl. Rep. Dep. Mines Tasm.*, 1976/41.

_____, Banks, M.R. and Rickards, R.B., 1978: Early Silurian Graptolites from Tasmania and their significance. *Search*, 9(1-2): 46-7.

Conybeare, C.E.B. and Crook, K.A.W., 1968: Manual of Sedimentary Structures. *Bur. Miner. Resour. Aust. Bull.*, 102.

Corbett, K.D. and Banks, M.R., 1974: Ordovician stratigraphy of the Florentine Synclinorium, southwest Tasmania. *Pap. Proc. R. Soc. Tasm.*, 107: 207-238.

Corbett, K.D. and Banks, M.R., 1975: Revised terminology of the Late Cambrian - Ordovician sequence of the Florentine - Denison Range area, and the significance of the "Junee Group". *Pap. Proc. R. Soc. Tasm.*, 109: 121-126.

Rickards, R.B., 1976: The sequence of Silurian graptolite zones in the British Isles. *Geol. J.*, 11(2): 153-188.

PLATE EXPLANATION

PLATE 1 (top left): Oscillation ripples, Gell Quartzite; Range Road (DN571587).

PLATE 2 (top right): Oscillation ripples with worm casts, Gell Quartzite; Range Road (DN 511587).

PLATE 3 (centre): Current oriented stipes of *Monograptus priodon*, x 1.3, Richea Siltstone; branch of Range Road (DN 512838).

PLATE 4 (bottom): Oscillation ripples in Currawong Quartzite; quarry at north end of Currawong Ridge (DN 508860).

Peter Baillie

Papers and Proceedings of the Royal Society of Tasmania, Volume 113, 1979

(ms. received 7.7.1978)

THE BOUNDARY RELATIONSHIP OF THE CONCERT SCHIST AND THE OONAH QUARTZITE AND SLATE CORRELATE AT DUNDAS

by N.J. Turner
Geological Survey of Tasmania

(with two text figures)

ABSTRACT

TURNER, N.J., 1979 (20 vii): The boundary relationship of the Concert Schist and the Oonah Quartzite and Slate correlate at Dundas. *Pap. Proc. R. Soc. Tasm.*, 113: 15-20. ISSN 0080-4703. Geological Survey of Tasmania, Department of Mines, Hobart, Tasmania, Australia.

The boundary between the metasedimentary Concert Schist (Precambrian) and the adjacent correlate of the relatively unmetamorphosed Oonah Quartzite and Slate (also Precambrian) at the western edge of the Concert Schist near its type section on Concert Creek near Dundas, Tasmania, is regarded as marking a sharp transition in degree of deformation and metamorphism. Three cleavages, mineral segregation and quartz recrystallisation were found in the Concert Schist whereas two cleavages and only minor mineral segregation and quartz recrystallisation were found in the Oonah Formation correlate.

Quartz optic axes fabrics obtained from psammites in the Concert Schist and Oonah Quartzite and Slate correlate are similar and show relatively weak preferred orientation. These fabrics and fabrics recorded earlier demonstrate that Precambrian strata in Tasmania which are classed as metamorphosed cannot in all cases be distinguished from those that are classed as relatively unmetamorphosed on the basis of quartz optic axes fabrics present in psammites.

INTRODUCTION

Blissett (1962) named the Concert Schist and defined it as 'that group of metasediments which appears to form the basement of the sedimentary succession in the Dundas district. The type section is on Concert Creek between co-ordinates 350500y E 844900y N (= CP 717639 Aust. Metric Grid) and 351700y E 845150y N (= CP 728641). He correlated the adjacent rocks with the Oonah Quartzite and Slate of Spry (1958). The Concert Schist was considered to be the older unit because it occurs in what was regarded as a structural high. Because of poor outcrop Blissett could not determine whether the unfaulted parts of the boundary between the units marked an unconformity or a transitional change in degree of metamorphism.

Spry (1962) subdivided the Precambrian rocks of Tasmania into metamorphosed and unmetamorphosed strata. A similar distinction has been employed at a regional scale in subsequent Geological Survey publications, for example, the 1:500,000 Geological Map of Tasmania (1976). However, the term relatively or comparatively unmetamorphosed has been used in preference to unmetamorphosed since there are no strictly unmetamorphosed Precambrian strata in the State. In relatively unmetamorphosed strata the pelitic rocks are generally slate and cleaved siltstone and the amount of quartz recrystallisation in psammites has generally been minor. In metamorphosed strata the pelitic rocks are generally phyllites or schists and there has been variable but, commonly, substantial recrystallisation of quartz in psammites. Although the terminology serves well enough at a regional scale, it breaks down at a local scale because there

are rocks that are relatively unmetamorphosed within sequences that are classed as metamorphosed. For example, Boulter (1974) described units of relatively unmetamorphosed siltstone and mudstone that occur within a sequence of dominantly phyllite, schist and quartzite near Strathgordon in the Tyennan region.

The metamorphosed terrains of the Tyennan region and the small Forth region are considered (Williams 1976) to have been produced by the Frenchman Orogeny and to be older than the relatively unmetamorphosed terrains. Within the relatively unmetamorphosed Rocky Cape region which includes the Oonah Quartzite and Slate there is a belt of metamorphic rocks known as the Arthur Lineament. North west of Dundas near Duck Ck. Blissett (op. cit.) found an apparent transition between a part of this belt known as the Whyte Schist and the Oonah Quartzite and Slate. Current interpretation of the boundary relationships of the entire Arthur Lineament (Williams, op. cit.) is that they are transitional. The metamorphosed belt and the widespread deformation in the relatively unmetamorphosed rocks were produced during the Penguin Orogeny.

The work reported in this paper was undertaken in order to establish the character of the boundary between the Concert Schist and the Oonah Quartzite and Slate correlate. Good exposure has been provided in recent years by the construction of a vehicular track along the spur immediately south of Concert Creek.

OONAH QUARTZITE AND SLATE CORRELATE

The part of this unit which outcrops along the track south of Concert Ck. between the Concert Schist and Maestries Siding comprises mainly grey and green, thinly bedded mudstone and siltstone. Thin beds of medium-grained, light-coloured or green sandstone are present in a few places although none were found in close proximity to where the Concert Schist boundary occurs on the track.

Argillaceous material in the mudstone and siltstone has recrystallised to fine-grained muscovite that shows strong alignment of flakes. Very fine-grained, 'dusty', opaque material is commonly intermixed with the muscovite and is probably carbonaceous. Small amounts of granular, opaque material are present in both mudstone and siltstone. The alignment of muscovite flakes is penetrative and defines a slaty cleavage. Commonly a weak crenulation cleavage is also present and there can be minor concentration of carbonaceous material in the limbs of crenulations.

The sparse beds of medium-grained sandstone are poorly sorted. They contain about 20% matrix consisting of fine-grained muscovite and equidimensional quartz and, in one sample abundant green chlorite. Sand-sized grains consist predominantly of undulose quartz with minor, micaceous quartzite and very-fine-grained, muscovite schist. Zircon and subhedral, opaque mineral are accessories. Alignment of muscovite flakes in the matrix is penetrative and defines a cleavage equivalent to the slaty cleavage in pelitic rocks. No evidence of crenulation of this cleavage was recognized. The cleavage wraps around the sand grains and beards are developed. In many grains, subgrains are present along margins that abut against beards and the entire margins of most grains are pitted indicating some tectonic mass transfer. Overall, the amount of textural modification appears to be minor. The axial ratios of almost all sand grains are less than 2:1 and the percentage of matrix probably is close to the percentage prior to deformation. The sandstone was originally quartzwacke.

In the 0.5 km interval west of Maestries Siding and east of the Cambrian ultramafic rocks the Oonah Quartzite and Slate correlate differs from the sequence described above. Sandstone is much more abundant and the interbedded pelitic material is mainly dark-grey, lustrous slate. The sandstone is fine- to medium-grained, white-weathering and micaceous. It contains about 20% matrix which consists of fine-grained muscovite and quartz. Sand grains are predominantly undulose quartz with minor, micaceous

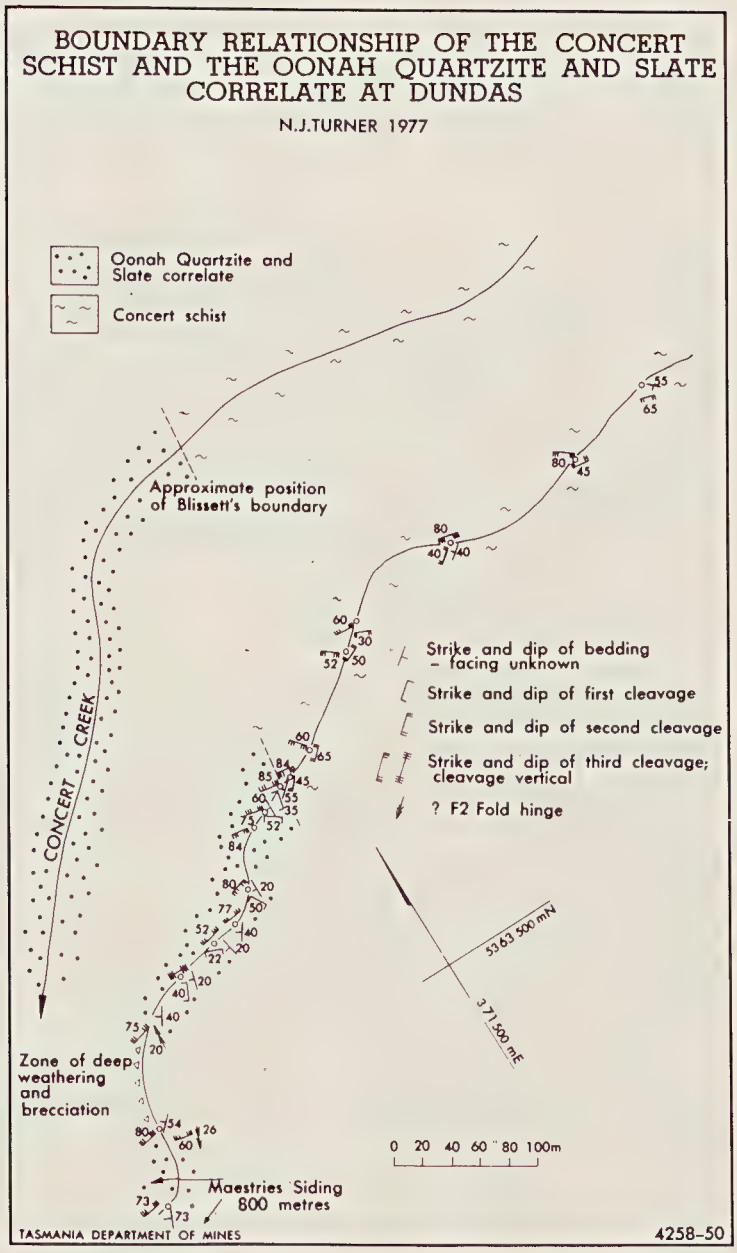

BOUNDARY RELATIONSHIP OF THE CONCERT SCHIST AND THE OONAH QUARTZITE AND SLATE CORRELATE AT DUNDAS
N.J.TURNER 1977
Oonah Quartzite and Slate correlate
Concert schist
Approximate position of Blissett's boundary
CONCERT CREEK
Strike and dip of bedding - facing unknown
Strike and dip of first cleavage
Strike and dip of second cleavage
Strike and dip of third cleavage; cleavage vertical
? F2 Fold hinge
5363 500 mN
371 500 mE
Zone of deep weathering and brecciation
0 20 40 60 80 100m
Maestries Siding 800 metres
TASMANIA DEPARTMENT OF MINES
4258-50

FIG. 1.- Structural measurements near the boundary of the Concert Schist and the Oonah Quartzite and Slate correlate.

quartzite and muscovite schist. Relatively coarse, detrital grains of muscovite are present. Because such grains are few in number and because the overall texture of the sandstone shows little modification and is that of a wacke, it is considered that such grains are wholly clastic. Cleavage morphology is similar to that in the sandstone described above, but there is little deflection of cleavage around sand grains, development of beards or of subgrains. Some quartz-rich patches in the matrix have a fine-grained, polygonal character similar to recrystallized material. However, the proportion of matrix and the shape of sand grains which almost all have axial ratios of less than 2:1 are thought to reflect the characteristics of the rock prior to deformation.

CONCERT SCHIST

Material in the portion of the Concert Schist examined is dominantly pelitic and semipelitic. Quartz and muscovite are the principal minerals. Dusty, very-fine-grained, probably carbonaceous material and disseminated, euhedral pyrite are abundant in some rocks. Secondary quartz, pyrite and green chlorite occur in small patches and veinlets in many rocks. Three tectonic surfaces are developed the second of which is dominant. In pelitic material the second surface is very closely spaced and difficult to distinguish as a crenulation cleavage in hand specimen, whereas in semipelitic rocks it has thin (0.5 - 1 mm) quartz-rich and mica-rich segregation laminae associated with it. The carbonaceous material segregates with the muscovite. Such rocks have a glossy, dark grey, phyllitic character. The first tectonic surface is preserved in some quartz-rich laminae as obliquely oriented fine-grained muscovite flakes and elongate quartz grains. The third surface is a weakly-developed crenulation cleavage which in hand specimen is more commonly evident as a lineation on the second surface than as a cleavage. Segregation of carbonaceous material can be associated with it but no segregation of quartz or muscovite was observed.

A number of beds of white or greenish white, foliated, micaceous quartzite of several metres thickness occur within the pelitic sequence about 1 km from the boundary on the track south of Concert Ck. They contain 5 - 10% muscovite plus accessory subhedral, opaque mineral and green tourmaline. Two surfaces are defined by preferred orientation of muscovite flakes. An older, poorly preserved, crenulated surface, defined by individual flakes, is transected by the dominant surface which is defined by stringers of muscovite. Two populations of quartz grains are present. Most grains are fine (0.04 mm), undulose, polygonal quartz, with smooth, gently curved or straight boundaries. In small patches such grains show dimensional orientation parallel to the older muscovite surface. A small proportion (10 - 15%) of grains are coarser (0.2 mm). These grains are strongly undulose and have low axial ratios. Their margins are irregular and commonly have subgrains developed along them. The subgrains are of similar size to grains in the groundmass and in many instances are intergrown with the groundmass grains such that there is no distinct boundary. This relationship indicates that the groundmass is derived in part from the coarser material by recrystallisation. Because the finer population shows dimensional orientation parallel to the older mica surface the coarser grains must be older than that surface. It is likely that they are modified clastic grains. However, no substantiating evidence, such as preserved sedimentary margins, was established. The third surface of the pelitic rocks was not observed in the quartzite units. The strong tectonic and metamorphic modification of the quartzite within the Concert Schist is in contrast with the sandstone of the Oonah correlate, particularly that west of Maestries Siding. Because of the modification, the type of sediment from which the quartzite was derived cannot be inferred.

N.J. Turner

STRATIGRAPHIC RELATIONSHIP

There is good exposure over the interval in which the boundary between the Concert Schist and the Oonah Quartzite and Slate correlate occurs (fig. 1). The following observations were made -

(1) No substantial change in lithology occurs although the pelitic and semipelitic rocks in the Concert Schist are richer in carbonaceous material than those adjacent to it.
(2) No erosional interface was detected.
(3) No fracturing or displacement indicative of substantial faulting was detected.
(4) There is a marginal increase in the lustre of some rocks in the Oonah correlate as the boundary is approached. In the Concert Schist at the boundary the rocks are more lustrous and mineral segregation associated with the second cleavage becomes evident.
(5) Bedding in the Concert Schist near the boundary is of similar attitude to bedding in the Oonah Formation correlate. Although bedding was not confidently identified in the Concert Schist at the boundary the second foliation, to which bedding is commonly sub-parallel, is of similar attitude to bedding in the Oonah formation correlate.

The absence of any indication of an erosional surface or of substantial faulting, combined with transition in lustre of the rocks and similar attitude of bedding indicates that there is no stratigraphic break between the Concert Schist and the Oonah Quartzite and Slate.

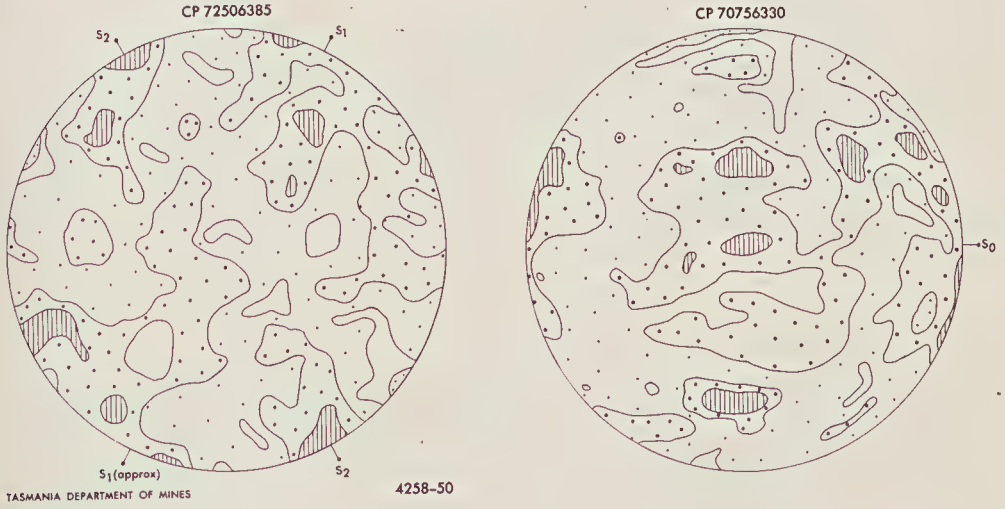


FIG. 2.- Quartz optic axes plots, 275 counts, contours 2, 1, 0%. Sections perpendicular to the dominant lineation. Left-hand plot: Concert Schist, about 1 km from boundary on spur south of Concert Ck., Dundas. Right-hand plot: Oonah Quartzite and Slate correlate, west of Maestries Siding, Dundas.

Boundary relationship of the Concert Schist and Oonah Quartzite and Slate Correlate

STRUCTURAL RELATIONSHIPS

The third tectonic surface of the Concert Schist has continuity across the boundary with the second surface in the Oonah Formation correlate and they are regarded as being the same. It has not been demonstrated which of the earlier surfaces in the Concert Schist is equivalent to the first surface in the Oonah Formation correlate. A few minor, open folds of short wave length and low amplitude occur in the Oonah Quartzite and Slate correlate. They post-date the earlier surface and pre-date the later. They have a crenulation lineation parallel to their hinges. The crenulation might be equivalent to the second surface in the Concert Schist and thus indicate that the first cleavages in the Concert Schist and the Oonah correlate are equivalent.

QUARTZ OPTIC AXES FABRICS

In view of the textural differences between the quartzite of the Concert Schist and the sandstone of the Oonah Formation correlate it was anticipated that their quartz optic axes fabrics would be substantially different. This is not the case. Both fabrics are diffuse, have very low intensity maxima and show triclinic symmetry (fig. 2). There is no increase in ordering in the Concert Schist quartzite although a large proportion of the quartz grains are of metamorphic origin.

Quartz optic axes fabrics comparable with those presented here were found by Spry (1964) in psammite from the relatively unmetamorphosed Donaldson Group of the Pieman R. area (Rocky Cape region) and by Spry (1963) in psammite from the metamorphosed Fisher Group in the upper Mersey R. area (Tyennan region). It is clear from Spry's results and those in this report that the two classes of Precambrian strata in Tasmania cannot be categorized by the type of quartz optic axes fabric present in their psammites. Although it is well established (e.g. Spry 1963) that rocks in the Tyennan Region can have quartz optic axes fabrics showing relatively strong preferred orientation, Spry's result for the Fisher Group psammite demonstrates that rocks having relatively weak preferred orientation are also present (c.f. Williams 1976, p. 6).

ACKNOWLEDGEMENTS

The author's attention was directed to the problem discussed in this paper by Dr. Emyr Williams, Supervising Geologist, Department of Mines who also provided helpful discussion during the course of the work. A.V. Brown, N. Farmer, and P.R. Williams aided by criticism of the manuscript.

REFERENCES

Blissett, A.H., 1962: One mile geological map series K/55-5-50 Zeehan. *Explan. Rep. geol. Surv. Tasm.*

Boulter, C.A., 1974: Tectonic deformation of soft sedimentary clastic dikes from the Precambrian rocks of Tasmania, Australia, with particular reference to their relations with cleavages. *Bull. Geol. Soc. Amer.*, 85: 1413-1420.

Spry, A.H., 1958: Some observations of the Jurassic dolerite of the Eureka Cone Sheet, near Zeehan, Tasmania; in DOLERITE - A SYMPOSIUM, Univ. of Tasm. 93-129.

_____, 1962: The Precambrian Rocks. In Spry, A. and Banks, M.R. (Eds): THE GEOLOGY OF TASMANIA. *J. geol. Soc. Aust.*, 9(2): 107-126.

_____, 1963: Ripple marks and pseudo-ripple marks in deformed quartzite. *Am. J. Sci.*, 261: 756-766.

_____, 1964: Precambrian rocks of Tasmania. Part VI. The Zeehan-Corinna area. *Pap. Proc. R. Soc. Tasm.*, 98: 23-48.

Tasmania Department of Mines, 1976: Geological map of Tasmania. Scale 1:500,000.

Williams, E., 1976: Tasman fold belt system in Tasmania. Explanatory notes for the 1:500,000 structural map of Pre-Carboniferous rocks of Tasmania. Department of Mines, Tasmania.

Papers and Proceedings of the Royal Society of Tasmania, Volume 113, 1979

(ms. received 10.2.1978)

BREATHING AND HEART RATES OF THE SOUTHERN ELEPHANT SEAL, *MIROUNGA LEONINA* (L.)

by Ron Kenny

Department of Zoology, James Cook University

(with three tables and one text figure)

ABSTRACT

KENNY, R., 1979 (20 vii): Breathing and heart rates of the southern elephant seal, *Mirounga leonina* (L.). *Pap. Proc. R. Soc. Tasm.*, 113: 21-27. ISSN 0080-4703. Department of Zoology, James Cook University, Townsville, Queensland, Australia.

Observations were made on resting southern elephant seals, *Mirounga leonina* (L.), on the beach. The breathing pattern of pups is typically regular with rapid, shallow inhalations. With increasing age a rhythmic pattern of alternating apneic and eupneic phases is developed. Apneic periods of similar duration to previously recorded dives were observed from adult seals. The heart rate decreases with increasing age; rates recorded from cows increased at the cessation of lactation and the onset of the breeding season; at other times rates from adult males and females were similar. Body temperatures were higher at the onset of the winter sea-going period than at other times of the year. The histology of the lungs and thyroid glands is typically mammalian.

INTRODUCTION

The physiology of the Pinnipedia has been reviewed by Harrison and Kooyman (1968). In general, statements on the physiology of the southern elephant seal *Mirounga leonina* (L.) have been concerned with body temperature (Laws 1956) and haematology (Bryden and Lim 1969; Seal *et al.* 1971; Lane *et al.* 1972). Few observations on breathing or heart rate have been found in the literature. Harnisch (1937) noted the frequency of breathing from a captive animal and Paulian (1957) recorded the number of inhalations between dives in the wild.

The physiology of the northern species, *M. angustirostris* including breathing and heart rates has been studied by Bartholomew (1954) who has commented on the irregular rhythm of the breathing pattern.

Swindle (1926) suggested the possibility of amphibious mammals "training" for diving, Bryden and Lim (1969) commented on changes in blood characteristics in elephant seals at the age of going to sea and Lane *et al.* (1972) suggested an increased diving potential in adult animals.

A general account of the biology of *M. leonina* at Macquarie and Heard Islands, where these observations were made, is given by Carrick *et al.* (1962).

METHODS

The present observations were made on resting elephant seals, on the beach at Macquarie Island (long. 159° E., lat. 54° S.) and Heard Island (long. 73° E., lat. 53° S.) between February 1948 and April 1951. Breathing rates were counted for several consecutive minutes from 194 individuals; 46 of the records were for periods exceeding 20 min. The heart rates of 278 individuals were obtained by direct observation of the movement of the body wall for a period of at least 1 min. The

majority of observations were made during the breeding season (October-November) and the adult moulting period (February-April) but occasional records are available from winter months.

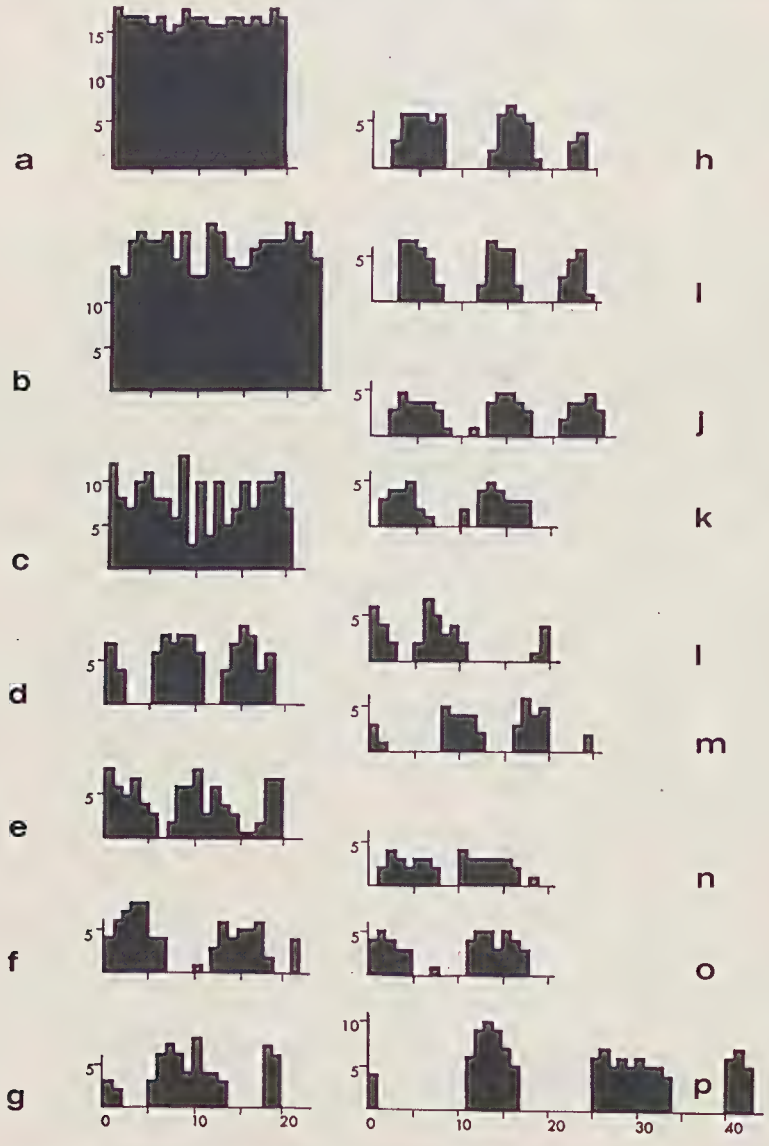


FIG. 1.- Selected examples of breathing patterns of elephant seals. horizontal axis - time in minutes; vertical axis - number of inhalations per minute. a,b.- pup; c.- young female prior to leaving beach; d,e.- pregnant female; f,g.- female lactating; h,i.- female after pup weaned; j,k.- young bachelor male; l,m.- old bachelor male; n,o.- harem bull; p.- bull moulting.

In conjunction with these observations other physiological data were noted. Rectal temperatures, recorded during daylight hours with a long stem mercury thermometer inserted to a depth of 0.2 m are available from 32 seals. Haematological information was recorded from 14 animals.

Lung (19 seals) and thyroid (24 seals) tissues from selected individuals were examined histologically. The samples were fixed in Bouin's fluid and stored in 4 per cent buffered formalin. Following paraffin embedding and sectioning, the tissues were stained with haemotoxylin and eosin for microscopic examination.

BREATHING RATE

The most striking features of the results are the variable rhythm of breathing apparent in the majority of adult seals and in contrast to this the more regular pattern of the younger seals. The extremes noted were 27 inhalations per min (male pup) and an apneic period of over 10 min (adult male, moulting). Details, from selected subjects, observed for approximately 20 min are shown in fig. 1.

The breathing of the pups is typically shallow, rapid, comparatively regular and at the rate of 10 to 20 inhalations per min. Some young animals showed tendencies towards the varied breathing rhythm of the adult. In general these animals were observed during April, just prior to going to sea for the winter period.

All the adult elephant seals observed had lower respiratory rates than those of young seals and showed some form of rhythmic variation of breathing rate. In general the pattern is one in which some minutes of eupnea are followed by a period of apnea of variable duration. These apneic phases may commence following either an inhalation or an exhalation, although the former pattern is more common.

The depth of the inhalations during eupnea and immediately preceding apnea varied considerably. In some individuals the breathing was deeper immediately preceding apnea while in others there did not appear to be any change from the comparatively shallow breathing of the eupneic phase. Similarly the initial inhalations following the pause in breathing varied considerably in depth.

The length of the period of apnea increases with age and the time of interspersed eupnea tends to decrease.

As an arbitrary comparison of the respiratory rate in elephant seals of differing age and activity, the mean number of inhalations over a period of 20 min have been calculated and are presented in table 1. The breathing rate is higher in young animals than in adults and among the adults varies with the activity pattern of the individuals. The variation for adult males in differing activity phases is considerably less than for females. The difference between the breathing rates of the adult males and females is more marked during the early summer pupping and mating haul-out than during the moulting period.

Development of the apneic pattern with increasing age supports the speculations of Swindle (1926), Bryden and Lim (1969) and Lane *et al.* (1972) that diving potential and ability are enhanced with age.

Harnisch (1937) observed variable respiratory rhythms and periods of apnea of 6 min duration from a zoo specimen of *M. leonina* and dives of 11 min were recorded by Paulian (1957) in the wild. Periods of submergence of 5 to 10 min alternating with periods of ventilation were noted by Laws (1956). The present results demonstrate that adult elephant seals on land experience apneic periods of similar duration to typical dives.

TABLE 1

MEAN NUMBERS OF INHALATIONS FOR 20 MINUTES
(commencing at the beginning of a period of eupnea),
calculated from all observations

pup	286	female		male	
		after weaning pup	108	immature	88
		pregnant	87	harem bull	48
		lactating	69	young bachelor	45
		moulting	48	old bachelor	41
				moulting	57

A similar respiration pattern was recorded from the northern elephant seal *M. angustirostris* by Bartholomew (1954) with a maximum inhalation rate of 23 per min and periods of apnea exceeding 8 min duration. Spontaneous variable breathing rhythms have also been observed from other aquatic mammals including the Florida manatee (Parker 1922; Scholander and Irving 1941), polar bear (Swindle 1926), fin whale (Gunther 1949), dugong (Kenny 1967) and various pinnipeds (Harrison and Kooyman 1968).

HEART RATE

The data from heart rate observations have been arranged by age and sex in table 2. The extremes recorded were 96 beats per min from a pup (age, approximately 1 month) and 23 from a bachelor bull. This follows the pattern noted from other mammals with the rate decreasing with increasing age and size.

The heart rates observed from pups were significantly higher (Student's "t" test, 1% level) than those from other sections of the population. Heart rates of immature seals were higher than those of adults (5% level) with the exception of cows after weaning their pups. The differences between the rates observed from different adult groups were not significant, except for those from cows at the end of the lactation period and the onset of the breeding season; these were significantly higher (1% level) than other adult heart rates.

Observations at 5 min intervals on individual seals showed changes in heart rate of up to 10 per cent without alterations in the activity pattern of the individual. No regular pattern of heart rate variability relative to breathing rhythms was noted, although Bartholomew (1954) observed a 15 per cent reduction of heart rate during apneic periods for *M. angustirostris*. Further, differences in heart rate before and after periods of apnea, similar to those recorded during experimental dives of other seal species (Harrison and Kooyman 1968) were not observed. Scholander (1940) has noted that reduction of heart rate is more marked during diving than during periods of apnea on land.

BODY TEMPERATURE

The mean elephant seal body temperature was 36.2°C, with a maximum of 38.4°C (immature male, April) and a minimum of 34.8°C (harem bull, October). This mean is similar to that given by Laws (1956) but he recorded a wider range of temperatures, in particular from moulting animals. Temperatures from immature seals ranged higher than those of adults in a pattern similar to the trend mentioned by Bartholomew (1954) for *M. angustirostris*; however, the records from the two groups were not significantly different.

All temperatures recorded in April (36.7 to 38.4°C) prior to the seals leaving the beaches, were above the mean value and higher than any breeding season or summer records.

TABLE 2

HEART RATES OF ELEPHANT SEALS

	Number of Observations	Heart rate, beats per minute max.	min.	mean	S.D.
pups	38	96	69	81	±5.7
male					
immature	58	71	35	54	±5.2
harem bulls	14	47	31	40	±2.8
old bachelors	18	50	23	36	±3.9
young bachelors	15	46	33	41	±3.1
moulting	26	50	26	43	±4.8
female					
immature	61	76	38	54	±5.4
pregnant	10	42	39	41	-
lactating	20	51	34	40	±2.6
after weaning pup	11	64	58	62	±1.3
moulting	7	51	39	47	±2.4
whole sample	278	96	23	53	

TABLE 3

ELEPHANT SEAL BLUBBER TEMPERATURES ^{o}C (APRIL)

	Blubber depth Air	1cm	5cm	10cm	Rectal
immature female	3.9	31.6	34.7		37.1
immature male	5.4	31.6	33.9		36.7
immature male	4.4	31.4	34.5		37.9
adult female	5.6	31.8	33.8		36.8
adult male	5.3	29.4	32.8	36.1	37.1

A series of subcutaneous temperature readings was taken from recently killed elephant seals. These are listed in table 3. The major shift in the heat gradient occurs in the skin and outer section of the blubber.

HAEMATOLOGY

The mean haemoglobin content of the southern elephant seal was 23.9 gm/100 ml of blood, which is similar to the figure given by Lane *et al.* (1972). The mean value for red cell counts was 3.39 x 10^{6}/ml. This is higher than the figure given by Lane *et al.* (1972) but similar to that given by Bryden and Lim (1969). The calculated oxygen capacity of 32.04 volume per cent is considerably lower than the value stated by Scholander (1940) but similar to that given by Lane *et al.* (1972).

HISTOLOGY OF LUNG

In view of the variable patterns of breathing associated with different ages and the lengthening of the apneic periods with increasing size, specimens of lung from elephant seals, selected to include a range of sizes, were examined microscopically. Measurements of alveolar diameter (mean of 12 from each sample) were made using an eyepiece micrometer.

The typical mammalian pattern of change in lung micro-anatomy applied, with alveolar size increasing regularly with body length. The smallest alveolar diameter, 0.03 mm, was recorded from a pup 1.29 m long and the largest, 0.12 mm, from an adult female 2.72 m in length.

No special micro-anatomical modifications were observed.

HISTOLOGY OF THYROID

The differences in breathing and heart rate associated with size and seasonal activity patterns prompted the histological examination of thyroid tissue samples.

The size of thyroid cells varied little in material from seals of different size or killed at different seasons, ranging from 0.013 mm to 0.017 mm in diameter. No obvious differences in amount of intracellular vacuolisation were noted.

The diameter of the follicles (mean of 12 follicles considered to be in maximum cross section) increased regularly with body length. The smallest noted was 0.09 mm from a pup 1.28 m long and the largest was 0.25 mm from a male 3.79 m in length. In a similar manner Harrison and Kooyman (1968) described a straight line relationship for the increase of thyroid weight relative to body weight in the harbour seal. Comparison of follicle sizes from seals of similar size at different times of the year showed little variation.

ACKNOWLEDGEMENTS

These observations were made under the auspices of the Australian National Antarctic Research Expeditions and the author wishes to thank the many members of that organisation who assisted. Dr. G.A. Bartholomew and Dr. G.C.L. Bertram kindly read the manuscript. The manuscript was prepared while the author was a visiting scholar at St. John's College, Cambridge.

REFERENCES

Bartholomew, G.A., 1954: Body temperature and respiratory and heart rates in the northern elephant seal. *J. Mamm.*, 35: 211-218.

Bryden, M.M. and Lim, G.H.K., 1969: Blood parameters of the southern elephant seal (*Mirounga leonina* Linn.) in relation to diving. *Comp. Biochem. Physiol.*, 28: 139-148.

Carrick, R., Csordas, S.E., Ingham, S.E. and Keith, K., 1962: Studies on the southern elephant seal *Mirounga leonina*, III. The annual cycle in relation to age and sex. *C.S.I.R.O. Wildlife Res.*, 7: 119-160.

Gunther, E.R., 1949: The habits of fin whales. *"Discovery" Rep.*, 25: 113-142.

Harnisch, O., 1937: Beobachtungen und Gedanken uber den Atemrhythmus der Pinnipedier. *Zool. Anz.*, 117: 225-232.

Harrison, R.J. and Kooyman, G.L., 1968: General Physiology of the Pinnipedia. In Harrison, R.J. *et al.* (Eds): BEHAVIOUR AND PHYSIOLOGY OF PINNIPEDS, Appleton Century Crofts, New York, 211-296.

Kenny, R., 1967: The breathing pattern of the dugong. *Aust. J. Sci.*, 29: 372-373.

Lane, R.A.B., Morris, R.J.H. and Sheedy, J.W., 1972: A haematological study of the southern elephant seal. *Comp. Biochem. Physiol.*, 42(A): 841-850.

Laws, R.M., 1956: The elephant seal (*Mirounga leonina* Linn.), II. General, social and reproductive behaviour. *Scient. Rep. Falkland Isl. Depend. Surv.*, 13: 1-88.

Parker, G.H., 1922: The breathing of the Florida manatee *(Trichechus latirostris)*. *J. Mamm.*, 3: 127-135.

Paulian, P., 1957: Note sur les phoques des Iles Amsterdam et Saint-Paul. *Mammalia*, 21: 210-225.

Scholander, P.F., 1940: Experimental investigations on the respiratory function in diving mammals and birds. *Hvalrad. Skr.*, 22: 1-131.

_____ and Irving, L., 1941: Experimental investigation of the respiration and diving of the Florida manatee. *J. Cell. Comp. Physiol.*, 17: 169-191.

Seal, U.S., Erickson, A.W., Siniff, D.B. and Cline, D.R., 1971: Blood chemistry and protein polymorphisms in three species of Antarctic seals *(Lobodon carcinophagus, Leptonychotes weddelli* and *Mirounga leonina)*. In Burt, W.H. (Ed.): ANTARCTIC PINNIPEDIA, *Am. Geophysical Un. Antarctic Res. Ser.*, 18: 181-192.

Swindle, P.F., 1926: Superimposed respirations or Cheyne - Stokes breathing of amphibious and non-amphibious mammals. *Am. J. Physiol.*, 79: 188-205.

Papers and Proceedings of the Royal Society of Tasmania, Volume 113, 1979

(ms. received 22.2.1978)

TASMANOCYPRIS, A NEW MARINE OSTRACODE GENUS: AND A REVIEW OF THE FAMILY PARACYPRIDIDAE (CRUSTACEA; OSTRACODA)

by K.G. McKenzie
Riverina College of Advanced Education, Wagga Wagga, N.S.W.

(with 32 figures)

ABSTRACT

McKENZIE, K.G., 1979 (20 vii): *Tasmanocypris*, a new marine ostracode genus: and a review of the family Paracyprididae (Crustacea; Ostracoda). *Pap. Proc. R. Soc. Tasm.*, 113: 29-37. ISSN 0080-4703. School of Applied Science, Riverina College of Advanced Education, Wagga Wagga, New South Wales, Australia.

Tasmanocypris, a new marine ostracode genus with the type species *T. dartnalli* n.sp., is described. Relationships between subfamilies and genera in the family Paracyprididae, to which it belongs, are discussed based on the recent literature and re-examination of some type materials.

INTRODUCTION

Working at Oyster Harbour, near Albany, Western Australia, the author identified as ? *Aglaiella setigera* (Brady, 1880) a large cypridid ostracode which occurred in the marine influenced southern Harbour, but found only females (McKenzie 1964, 1969). The taxon continued to be of interest with the description of several related ostracodes from South Africa (Benson and Maddocks 1964, Hartmann 1974) and the discovery of a fossil Australian species (McKenzie 1974). Recently, a population which included several males was collected off Little Swanport, Tasmania, and it is at last possible to give a complete description. This necessitates the erection of a new genus and has led to a review of the family to which it belongs.

SYSTEMATIC DESCRIPTION

Subphylum	OSTRACODA Latreille, 1806
Class	PODOCOPIDA Müller, 1894
Order	METACOPINA Sylvester-Bradley, 1961
Superfamily	CYPRIDACEA Baird, 1845
Family	PARACYPRIDIDAE Sars, 1923
Subfamily	PARACYPRIDINAE Sars, 1923 (partim)
Genus	*TASMANOCYPRIS* n. gen.

Synonymy: *Macrocypris* (partim) Brady, 1880 - ? *Aglaiella* McKenzie 1964, 1969, 1974.
Type Species: *Tasmanocypris dartnalli* n.sp.
Derivation of Name: From Tasmania and the generic suffix - *cypris*.
Diagnosis: Subtriangular paracypridinid; anterior and posterior margins subequally rounded; left valve slightly larger than right valve; valve surfaces smooth, micropunctate and pigmented (at least in the type species); relatively large, over 1 mm in all three known species; greatest height median; dorsal view, regularly elliptical; selvage weak; inner lamellae broad with large anterior and posterior vestibules; marginal (radial) pore canals numerous and branched; normal pore canals scattered, simple, open; hinge of ridge and groove type; adductor muscle scars clustered in the typical paracypridinid pattern, with an overlying elongate scar (sometimes divided)

plus three anterior and two posterior scars, and with two mandibular scars. Antennule 7-segmented with stout terminal spines; antenna with reduced 'natatory' setae; mandible coxale with 4-5 cuspate teeth; maxillule third lobe with three smooth Zahnborsten; maxilla (P I) endopod lobate, undivided in females, but a two-segmented clasping organ in males; walking leg (P II) powerful; P III with a distinct terminal segment and undivided long reflexed terminal bristle; furca with 2 serrate claws, an anterior bristle and two prominent posterior bristles; Zenkers Organ with five whorls of spines (Chitinrosettes); tubes of the testes forming near circles and opening dorsally.

Remarks

The size of this new genus and the ascription of a 'Challenger' species to *Macrocypris* (Brady 1880) led to an initial assignment of this taxon to Macrocyprididae But the hinge, muscle scars and soft anatomy are all paracypridid-like. The new genus is closest to *Phlyctenophora* Brady, 1880 which is also a typical paracypridine genus in Australasian waters but differs from *Phlyctenophora* particularly in its regularly subtriangular shape because *Phlyctenophora* is more pointed posteriorly. Further, the posterior bristles on the furca differ between these genera (Brady 1880).

Probably, a neotype is required for *Phlyctenophora zealandica* since the available syntypes differ from the concept of this species given by Brady and do not include specimens from Wellington Harbour which the species name indicates as the type locality Abundant material of the original sediment collected from Wellington Harbour during the 'Challenger' expedition is available at the British Museum (Natural History).

The short antennal 'natatory' setae and Zenkers Organ with five Chitinrosettes relate *Tasmanocypris* to Candonidae, but candonids are predominantly freshwater forms also have different radial pore canals and different furcae. Cyclocypridines are also related but typically much smaller and subcircular in shape. Thalassocypridines are smaller, have different marginal pore canals and characterise different habitats - estuarine or freshwater. These relationships are considered further after description of the type species.

Tasmanocypris dartnalli n.sp.
(figs 1-23)

Derivation of Name: from its collector, A.J. Dartnall, Zoology Department, the University of Tasmania.

Type Material:

Holotype: mature male; Australian Museum Reg. No. P.26683.
Paratype: ovigerous female; Australian Museum Reg. No. P.26684

Further paratypes are stored at the Tasmanian Museum, Hobart; the British Museum (Natural History), London; and the Smithsonian Institution, Washington.

Description

Carapace large; regularly subtriangular; anterior and posterior subequally rounded; dorsum convex; venter almost straight, slightly inflexed anteromedially; surface smooth, micropunctate, with scattered hairs; colour often dark brown at the extremities and near the dorsum; soft parts yellowish brown, ova orange brown; greatest height medial and less than half the length; in dorsal view, regularly elliptical; greatest breadth medial and over two-fifths the length. Internally: lamellae broad anteriorly and posteriorly, narrow ventrally; zone of concrescence relatively narrow throughout; selvage very weak, submarginal; radial pore canals typically branched, especially anteriorly and very numerous; normal pore canals scattered, simple, open; hinge weakly lophodont, with elongate low terminal elements in the right valve and an accommodation groove in the slightly larger and over-lapping

left valve; adductor muscle scars clustered in a rosette comprising an elongate upper scar (sometimes divided), three anterior and two posterior scars, plus two mandibulars, other scars not observed.

Antennule 7-segmented; length ratios of the segments 80:15:25:20:17:16:12; dorsal/ventral chaetotaxy of the segments 1/2, 1/1, 1/1, 2/2, 2/2, 2/2, plus two terminal spine-like bristles. Antenna 5-segmented; length ratios of the three endopod segments 6:5:3; ventral sensory bristle of the first endopod segment sutured medially, 'natatory' setae short, 7 in number and sited distally on the segment, ventrodistally is a long bristle, serrate from its mid-length and terminating in a long sensory filament; second segment with the usual complement of bristles and two dorsodistal claws; third segment with four terminal claws and several bristles including a club bristle with a long sensory filament; exopod modified as a long spiky bristle sited proximodorsally on the first endopod segment. Mandible coxale with 4-5 cuspate teeth and small toothbrush bristles between at least the first two of these; endopod 4-segmented bearing an epipod with 5 Strahlen; chaetotaxy as illustrated and including 3 terminal claws. Maxillule palp and lobes normal; distal segment of the palp broad; third lobe with 3 smooth Zahnborsten; epipod with 18 Strahlen plus 3 downwards directed setae. Maxilla (P I) in females with an unsegmented endopod bearing three short terminal setae; epipod with 5 Strahlen; exopod with about 15 strong bristles; in males the palps are modified into the usual cypridacean clasping organs. P II 5-segmented; length ratios of the segments 50:65:40:30:12; chaetotaxy normal; margins of the three penultimate segments bearing several clumps of hairs, as illustrated; terminal claw powerful. P III reflexed; 4-segmented; length ratios of the last 3 segments 70:80:12; terminal segment distinct with two small hooked setae and a long reflexed seta which is hirsute from its mid-length and serrate for the last 25% of its length. Chitin support with a simple blunted tip, forked distally; the anterior branch straight, the posterior branch strongly recurved. Furca powerful; length:height ratio about 10:1 measured at the mid-length; armature of 2 large claws, the anterior:posterior claw ratio 4:3, both claws strongly serrate distally; bristles comprising one anterior and two posterior, the longest of these being the first posterior bristle. Labrum simple, labium with a tuft of hairs. In males: Zenkers Organ with 5 Chitinrosettes; hemipenis with a large tapering basal lobe and tongue-like anterior process. Cups of the nauplius eye fused.

Dimensions - Holotype, male: length 1.19 mm, height 0.56 mm, breadth 0.55 mm.
Paratype, female - length 1.21 mm, height 0.57 mm, breadth 0.57 mm.
Type Locality - Little Swanport, east coast of Tasmania, at about Lat. 42°17'S. Collected at eight stations, their depths varying from about 3.2 m to 18.5 m. The substrate is mostly well sorted sand with MD around 2.50 ϕ; specific permeability determinations demonstrate that most of these sands are two phase (A.J. Dartnall personal communication, December 1977).
Distribution - The species has also been collected from Bull Bay, NE Bruny Island, Tasmania.
Other Species - The only other living species in the genus appears to be *Tasmanocypris setigera* (Brady, 1880) which ranges from Oyster Harbour, near Albany, Western Australia, to Port Jackson, Sydney, New South Wales. Unfortunately, the syntypes of *T. setigera* deposited in the 'Challenger' collection at the British Museum (Natural History), London, do not match Brady's type description and selection of a neotype from the original sediment is necessary. Another species occurs fossil 2 m above the base of the type Mitchellian section at the Pumping Station locality, Bairnsdale, Victoria. It was previously identified as ? *Aglaiella* sp. (McKenzie 1974).
Geologic Range - Neogene-Recent.

RELATIONSHIPS IN THE FAMILY PARACYPRIDIDAE

Paracyprididae are a distinctive family of cypridacean ostracodes, comprising the subfamilies Paracypridinae, Thalassocypridinae and Cyclocypridinae with the following

common features: an onion-shaped entrance to the Zenkers Organ; a two-segmented clasping organ in the male P I; and the occurrence of natatory setae on the antennae, although these are often reduced. These common characters separate them from Candonidae which otherwise are closely related (Hartmann and Puri 1974). Probably, Candonidae diverged from an ancestral paracypridid-like stock in the Late Mesozoic.

Some paracyprids are homeomorphic with genera in the family Macrocyprididae. In particular, *Tasmanocypris* is homeomorphic with *Macrocyprina* and *Phlyctenophora* with *Macrocyprissa*. Macrocyprids, however, have a well developed hinge structure with prominent crenulate terminal elements and a characteristic muscle scar pattern (Triebel 1960), criteria by which they can be readily distinguished from other Ostracoda. They differ very strongly from paracypridids in the soft anatomy also and research in hand will no doubt be definitive in establishing their relationships (Dr. R.F. Maddocks personal communication, October 1977).

As understood herein, the family Paracyprididae comprises the following subfamilies and genera:

1. Subfamily Paracypridinae Sars, 1923 with the living genera *Paracypris* Sars 1866; *Phlyctenophora* Brady 1880; *Aglaiella* Daday 1910; *Aglaiocypris* Sylvester-Bradley 1947; *Ghardaglaia* Hartmann 1964; *Coralliaglaia* Hartmann 1974; and *Tasmanocypris* n.gen.
2. Subfamily Thalassocypridinae Hartmann and Puri 1974 with the living genera *Thalassocypris* Hartmann 1955; *Thalassocypria* Hartmann 1957; *Pontoparta* Vavra 1901; *Parapontoparta* Hartmann 1955; *Paracypria* Sars 1910; *Dolerocypria* Tressler 1937; *Allocypria* Rome 1962; *Mecynocypria* Rome 1962; and *Mungava* Harding 1962.
3. Subfamily Cyclocypridinae Kaufmann 1900 with the living genera *Cyclocypris* Brady and Norman 1889; *Cyclocypria* Dobbin 1941; *Cypria* Zenker 1854; *Physocypria* Vavra 1898; and *Candocypria* Furtos 1933. In a later paper, Dobbin (1969) noted that she believed the type species of her genus *Cyclocypria* to be a late instar of a *Cyclocypris* species.

No fossil thalassocypridines are as yet known but fossil taxa which have been assigned to the other two subfamilies range from the early Mesozoic.

The approach used to determine the interrelationships between these taxa has been to re-examine type materials of some inadequately known genera and synthesise from the literature and the results of such re-examinations. This task has been simplified recently by the publication of well illustrated faunas from southern Africa and southwest Florida in which several relevant genera occur (Hartmann 1974, Keyser 1975).

There is no problem in distinguishing paracypridines from cyclocypridines because, whereas paracypridines are elongate or bean-shaped and relatively large (about 1 mm), the cyclocypridines are typically subcircular in outline and relatively small (about 0.5 mm). Further, cyclocypridines usually have long antennal natatory setae but these setae are reduced in paracypridines. The single known Australian exception to this last generalisation is a Tasmanian cyclocypridine which was collected in 1966 from moist forest moss at the edge of Arthur Plains, southwest Tasmania. When dissected it was found to be blind and to have reduced antennal natatory setae (presumably so adapted for its semiaquatic terrestrial habitat) although otherwise a typical cyclocypridinid.

The distinctions between paracypridines and thalassocypridines are less obvious because all thalassocypridine genera are more or less elongate or bean-shaped. With respect to other shell characters, paracypridines are well calcified and typically have numerous branched radial pore canals but thalassocypridines are thinner shelled and have less numerous straight (unbranched) radial pore canals. Usually, paracypridines are larger than thalassocypridines.

On soft parts, several characters are commonly used to distinguish between genera

in the two subfamilies. Unfortunately, re-examination of types indicated that some of these characters were incorrectly observed and illustrated in the original generic descriptions. Such errors are corrected here.

All thalassocypridines have 7-segmented antennules (except *Thalassocypria aestuarina* Hartmann 1957 in which it is 6-segmented) whereas in paracypridines the number of antennular segments is 5 in *Ghardaglaia* and *Coralliaglaia*, 6 in *Aglaiella* and 7 in the four remaining genera. With the exception of *Dolerocypria*, the antennal natatory setae of all thalassocypridine genera are well developed, extending beyond the tips of the terminal claws; and even in *Dolerocypria* they extend to the mid-length of the claws. In all paracypridines these antennal natatory setae are reduced, reaching barely beyond the second endopod segment in *Ghardaglaia*, *Aglaiocypris*, *Aglaiella* and *Paracypris* and even shorter in *Phlyctenophora* and *Tasmanocypris* (in *Coralliaglaia* they are reduced in number also, to a single short seta).

In some other characters, the two subfamilies seem to have evolved in parallel. For example, both *Dolerocypria* a thalassocypridine, and *Tasmanocypris*, a paracypridine, carry three smooth Zahnborsten on the maxillule third lobe, while two toothed Zahnborsten are the usual complement of this lobe in the other genera of both subfamilies with minor variations in the type of toothing. In *Dolerocypria*, the penultimate segment of the cleaning limb is sutured medially (re-examination of holotype) and it is divided in *Paracypris*, *Coralliaglaia*, *Paracypria* and *Pontoparta* (Müller 1912, Sars 1923, Harding 1962, Hartmann 1974) but in other thalassocypridines and paracypridines it is neither divided nor sutured. The chitin supports of all paracypridines and thalassocypridines are very similar.

A character which is usually conceded importance in determining cypridacean relationships is the furca. In both subfamilies, the furcal shaft carries two powerful claws which are often coarsely serrate, e.g. *Parapontoparta*, *Tasmanocypris*, and in all genera there is a small bristle above the anterior claw. But the number of posterior bristles varies, being either one or two in most cases. Sometimes, they are reported as absent, e.g. *Thalassocypris*. In several taxa, one or two stiff hairs occur on the margin behind the posterior claw and seem to be homologous with the posterior bristles in other genera. These stiff hairs can be found in genera which were originally described as carrying only one or as lacking posterior bristles. Thus, the holotype of *Dolerocypria*, which was described as having a single posterior bristle (Tressler 1937) has in fact two stiff hairs behind the posterior furcal claw. Tressler's mention of a posterior bristle apparently confused Keyser (1975) who could not see a bristle on the holotype, whereas the stiff hairs are clearly visible under high power using a light microscope. In the original description of *Paracypria* also, it was recorded that the furca lacked posterior bristles but careful re-examination of the holotype slide has led to the discovery of a single stiff hair behind the posterior claw. Prominent single posterior bristles characterise the thalassocypridine genera *Mungava*, *Mecynocypria* and *Allocypria*. All paracypridines have two posterior bristles. In *Paracypris*, these are prominent and about equally long, in *Ghardaglaia*, *Aglaiocypris*, *Aglaiella* and *Coralliaglaia* they are small and equal, in *Phlyctenophora* both are prominent with the posterior longer than the anterior bristle and in *Tasmanocypris* this situation is reversed because the anterior bristle is longer.

Environmentally, thalassocypridines occur in estuaries, among mangroves, in saline oases or else are freshwater adapted (Hartmann 1955, 1957, Tressler 1937, Harding 1955, 1962, Rome 1962, Keyser 1975). All paracypridines, on the other hand, are marine adapted but some species have been described from marine estuaries, strongly brackish environments such as the Mareotis, near Alexandria, or the saline Red Sea (Daday 1910, Brady 1868, 1880, Sars 1923, Hartmann 1964, McKenzie 1967). These differing environmental preferences suggest that thalassocypridines evolved from paracypridines and represent a continuing continental invasion by descendants of that older stock.

ACKNOWLEDGEMENTS

Mr. A.J. Dartnall returned to the type locality when he knew of my interest in the taxon and collected at several stations. His material provided first specimens of the hitherto elusive males. The United States Museum of Natural History: Smithsonian Institution, Washington, D.C. (Dr. L.S. Kornicker), forwarded the types of *Dolerocypria taalensis* Tressler, 1937 - USNM 71515, Acc. No. 139464. The Zoological Museum, Oslo (Dr. M. Christiansen) provided the types of *Paracypria tenuis* (Sars, 1905) Reg. Nos. F 11756 (female) and F 11757 (male). The Hancock Museum, Newcastle-upon-Tyne (Mr. A. Tynan) loaned the types of *Aglaiocypris pulchella* (Brady, 1868) - No. B 62. The available material of *Tasmanocypris setigera* (Brady, 1880) and of *Phlyctenophora zealandica* Brady, 1880 in the 'Challenger' collection at the British Museum (Natural History) were examined some years ago when the author was a member of the staff. The Natural History Museum, Vienna (Dr. G. Pretzmann) loaned the types of *Aglaiella stagnalis* Daday, 1910. Mrs. A. Perry typed the manuscript. The research was partially supported by A.R.G.C. grant D 76/15127.

REFERENCES

Benson, R.H. and Maddocks, R.F., 1964: Recent ostracodes of Knysna Estuary, Cape Province, Union of South Africa. *Univ. Kansas Paleont. Contribs., Arthropoda,* 5: 1-22.

Brady, G.S., 1868: 'LES FONDS DE LA MER Part I'. 316 pp. Folin and Perrier, Paris.

_____, 1880: Report on the Ostracoda dredged by H.M.S. Challenger during the years 1873-1876. *Challenger Reps., Zool.,* 1(3): 1-184.

Daday, E. von, 1910: Ergebnisse der mit subvention ans der Erbschaft traits unternommenen zoologischen forschungsreise Dr. Franz Werner's nach dem Aegyptischen Sudan und Nord-Uganda. XV. Beitrage zur Kenntnis der Mikrofauna des Nils. *Akad. Wiss., Wien, Math. Nat. Kl.,* 119: 537-568.

Dobbin, C., 1969: Designation of lectotypes of freshwater species described by Dobbin, 1941 (Ostracoda, Crustacea). In Neale, J.W. (Ed.): THE TAXONOMY, MORPHOLOGY AND ECOLOGY OF RECENT OSTRACODA. Oliver and Boyd, Edinburgh. 491-494.

Harding, J.P., 1955: The Armstrong College Zoological Expedition to Siwa Oasis (Libyan Desert) 1935. Crustacea: Branchiopoda and Ostracoda. *Proc. Egypt. Acad. Sci.,* 10: 58-68.

_____, 1962: *Mungava munda* and four other new species of ostracod crustaceans from fish stomachs. *Nat. Hist. Rennell Island, British Solomon Islands,* 4: 51-62.

Hartmann, G., 1955: Neue marine Ostracoda der familie Cypridae und der subfamilie Cytherideinae der familie Cytheridae aus Brasilien. *Zool. Anz.,* 154(5/6): 109-127.

_____, 1957: Zur Kenntnis des Mangrove-Estero-Gebietes von Salvador und seiner Ostracoden - fauna II. *Kiel.Meeresforsch.,* 13(1): 134-159.

_____, 1964: Zur Kenntnis der Ostracoden des Roten Meeres. *Kiel.Meeresforsch.,* 20: 35-127.

_____, 1974: Zur Kenntnis des Eulitorals der afrikanischen Westkuste zwischen Angola und Kap der Guten Hoffnung und der afrikanischen Ostkuste von Sudafrika and Mocambique unter Berucksichtigung der Polychaeten und Ostracoden. Teil III. Die Ostracoden des Untersuchungsgebiets. *Mitt. Hamburg. Zool. Mus. Inst.,* 69: 229-520.

Hartmann, G. and Puri, H.S., 1974: Summary of Neontological and Paleontological classification of Ostracoda. *Mitt. Hamburg. Zool. Mus. Inst.,* 70: 7-73.

Keyser, D., 1975: Ostracoden aus den Mangrovegebieten von Sudwest-Florida. *Abh. Verh. naturwiss. Ver. Hamburg,* 18/19: 255-290.

McKenzie, K.G., 1964: The ecologic associations of an ostracode fauna from Oyster Harbour, a marginal marine environment near Albany, Western Australia. *Pubbl. staz. zool. Napoli,* 33 suppl.: 421-461.

_____, 1967: Recent Ostracoda from Port Phillip Bay, Victoria. *Proc. R. Soc. Vict. n.s.,* 80(1): 61-106.

McKenzie, K.G., 1969: Species list. In Neale, J.W. (Ed.) THE TAXONOMY, MORPHOLOGY AND ECOLOGY OF RECENT OSTRACODA, Oliver and Boyd, Edinburgh, 11-13.
_____ 1974: Cenozoic Ostracoda of southeastern Australia with the description of *Hanaiceratina* new genus. *GeoScience and Man*, 6: 153-182.
Müller, G.W., 1912: Ostracoda. *Das Tierreich*, 31: 1-434.
Rome, Dom R., 1962: Ostracoda. *Result. sci. Explor. hydrobiol. Lac Tanganika*, 3(8): 1-305.
Sars, G.O., 1905: Pacifische plankton - crustaceen (Ergebnisse einer reise nach dem Pacific. Schauninsland 1896-1897). II Brackwasser - crustaceen von den Chatham-Inseln. *Zool. Jb. Abt. Syst. Geog. Biol.*, 21: 371-414.
_____, 1923: Ostracoda. In AN ACCOUNT OF THE CRUSTACEA OF NORWAY. 9(3/4): 33-72 (Bergen Museum: Bergen).
Tressler, W.L., 1937: Ostracoda. *Internat. Rev. ges. Hydrobiol. Hydrog.* 34(3/5): 188-207.
Triebel, E., 1960: Die taxionomische Stellung und die Gattungen der Unterfamilie Macrocypridinae (Ostracoda). *Senck. biol.*, 41(1/2): 109-124.

FIGURE EXPLANATIONS

Tasmanocypris dartnalli n.gen., n.sp., adult male, holotype, AM P.26683. Figure 2, adductor muscle scars; fig. 5, detail serrate bristle and club-shaped bristle antennal endopod; fig. 8, detail sensory bristle, proximoventral first antennal endopod segment; fig. 11, maxillule third lobe with 3 Zahnborsten; fig. 13, hemipenis; fig. 14, left palp P I; fig. 15, right palp P I; fig. 17, Zenker's Organ; fig. 23, P III.

Adult female, paratype, AM P.26684. Figure 1, internal view carapace left valve; fig. 3, antennule; fig. 4, antenna; fig. 6, maxillule palp and lobes (segments only); fig. 7, P I; fig. 9, P I endopod; fig. 10, labrum; fig. 12, mandible coxa; fig. 16, mandible endopod; fig. 18, chitin support; fig. 19, furca; fig. 20, detail, end of long reflexed bristle, P III; fig. 21, P II endopod; fig. 22, P II protopod.

Aglaiella stagnalis Daday, 1910, adult female, co-type, Natural History Museum, Vienna. Figure 24, maxillule palp and third lobe with Zahnborsten; fig. 25, P I (part only); fig. 26, detail, terminal segment, P III; fig. 29, detail, end of long reflexed bristle, P III; fig. 30, antenna, detail showing 'natatory' setae; fig. 32, anterior furca.

Paracypria tenuis (Sars, 1905), adult male, co-type, Zoological Museum, Oslo, Reg. No. 11757. Figure 27, anterior furca; fig. 31, chitin support.

Adult female, co-type, Zoological Museum, Oslo, Reg. No. 11756. Figure 28, chitin support.

Magnifications: Fig. 1-x 80.
Figs 2-4, 6, 7, 9, 10, 12-19, 21-23, 28, 31-x 200.
Figs 24, 25, 27, 30, 32-x 400.
Figs 5, 8, 11, 20, 26, 29-x 800.

1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16

17
18
19
20
21
22
23
24
25
26
27
28
29
30
31
32

Papers and Proceedings of the Royal Society of Tasmania, Volume 113, 1979

(ms. received 4.12.1978)

LATE PLEISTOCENE BONE DEPOSITS FROM A CAVE IN THE FLORENTINE VALLEY, TASMANIA

by A. Goede and P. Murray
University of Tasmania and Tasmanian Museum

(with six text figures, one table and five plates)

ABSTRACT

GOEDE, A. and MURRAY, P., 1979 (20 vii): Late Pleistocene bone deposits from a cave in the Florentine Valley, Tasmania. *Pap. Proc. R. Soc. Tasm.*, 113: 39-52 (incl. five plates). ISSN 0080-4703. Department of Geography, University of Tasmania, Hobart, Tasmania and Tasmanian Museum and Art Gallery, Hobart, Tasmania, Australia.

A limestone shelter cave in the Florentine Valley, south-central Tasmania, has yielded vertebrate remains. Two of the three sites excavated have yielded evidence of the presence of elements of the Pleistocene megafauna. The morphology and stratigraphy of the cave is described. Pleistocene deposits are shown to consist of two units. A lower unit laid down by water with an admixture of roof fall and an upper unit of angular limestone detritus derived from physical weathering within the cave entrance. C-14 dating indicates a late Pleistocene age for material collected from one of the sites. Its stratigraphic relationship to the other sites is discussed.

INTRODUCTION

Palaeontological and geomorphological investigations were carried out in Titans Shelter, a limestone shelter cave, in 1976 and 1977. It is located just below the crest of a limestone hill at an elevation of 400 m within the broad valley of the Florentine River some 23 km north-northwest of Maydena (146°28'9"E, 42°34'57"S). It is approximately 1.4 km south-southwest of Beginners Luck Cave where the authors have previously investigated a Pleistocene archaeological bone site (Goede and Murray, 1977) (figure 1).

Excavations were made at three sites (E, F and G) and all have yielded vertebrate remains (figure 2). Site G proved the most rewarding containing a number of extinct species which included *Macropus titan*, *Protemnodon* sp., *Sthenurus* sp., *Sarcophilus* sp. and an unidentified diprotodontid. The bones at this site have been extensively chewed and fragmented suggesting derivation from a carnivore's den - probably occupied by *Sarcophilus*. The small passage from which the material entered the chamber is at present inhabited by *Sarcophilus harrissii* as evidenced by fresh coprolites found during some of our visits.

CAVE DESCRIPTION

The cave has developed in well-bedded Ordovician limestone (Gordon Limestone) locally dipping south-west at an angle of some 25°. The cave is shown in plan in figure 2 and in longitudinal section in figure 3. The cave mouth is situated in a steep anti-dip slope close to the crest of the hill and consists of a wide, low opening (5 x 2.2 m) facing north-east (plates 1 and 2). The cave floor slopes steeply inwards at a maximum angle of 35° from the crest of a natural rampart approximately three metres outside the roof line of the entrance. The roof of the entrance chamber looks unstable and descends in a series of steps formed by roof fall parallel to the bedding. Despite the unstable appearance of the roof there has been little recent roof fall as evidenced by joint-aligned rows of spongy stalactitic formations covered by algal growth.

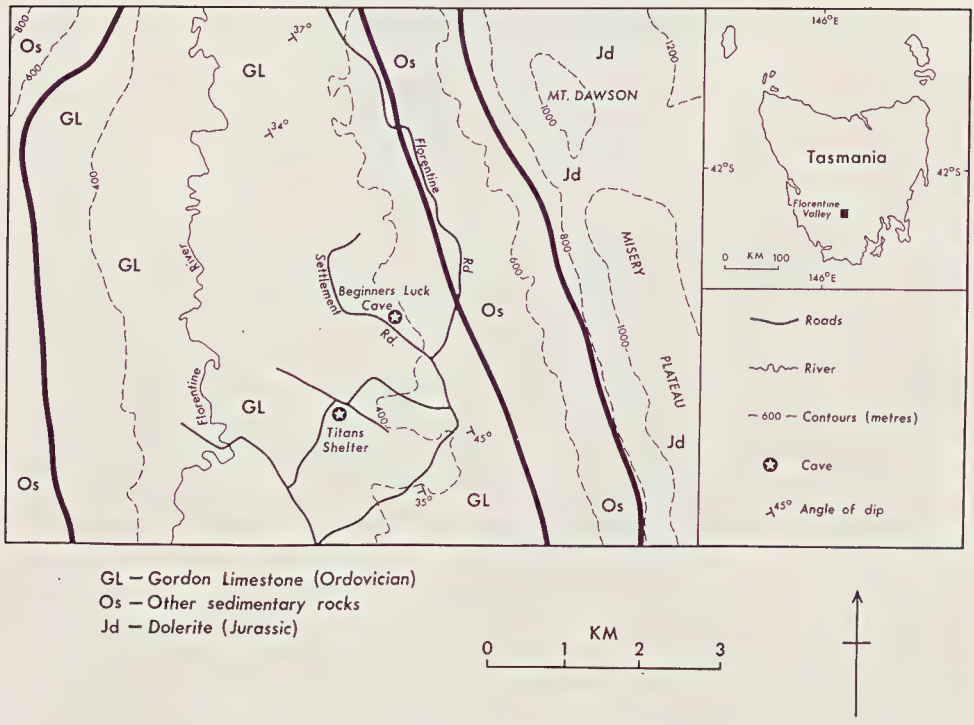


FIG. 1.- Locality and lithological map of part of the Florentine Valley (lithology after Corbett 1963).

The floor is partly covered by slabs of roof fall - the largest being 2.0 x 2.3 x 0.35 m. These are partly imbedded in a dull yellowish brown (10 YR/4/3) (Standard Soil Color Chart 1965) cave earth mixed with an abundance of smaller limestone fragments and containing significant amounts of charcoal and organic matter. Much of the surface charcoal was derived from burning of slash in the summer of 1975-76 following clearfelling.

The entrance chamber has maximum dimensions of 8 x 9 m with a maximum ceiling height of 2.3 m. Along the south-western wall approximately 40 cm below the ceiling a wide, low-roofed extension slopes downward at an angle of 20° becoming too tight for human penetration after about three metres. It has a bedrock ceiling and a floor consisting of clastic sediments.

At the lowest point of the entrance chamber the roof steps down to a point where large roof fall originally blocked further access. A small opening against the south-western wall was enlarged to provide entry to a second chamber.

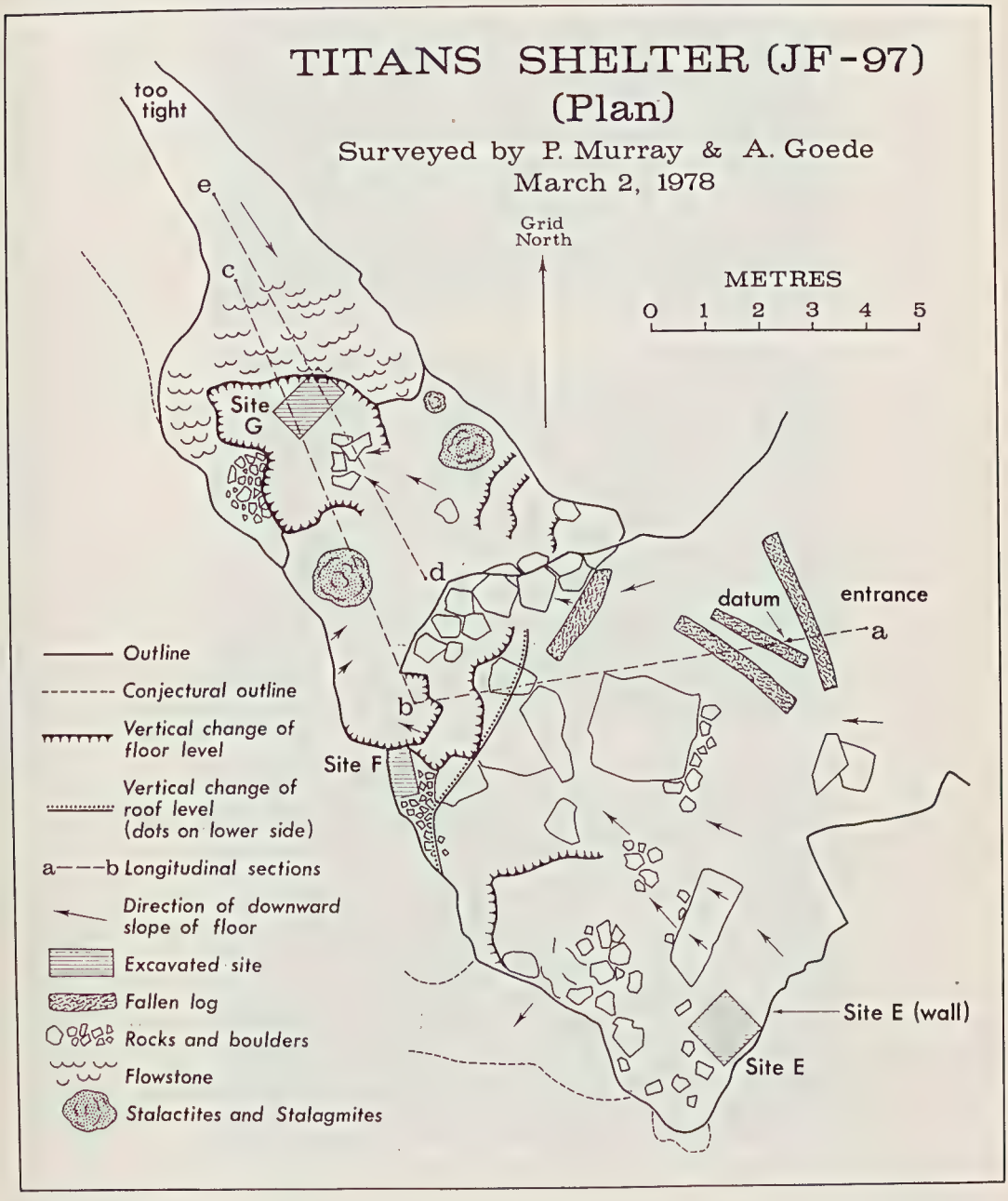


FIG. 2.- Plan survey of Titans Shelter.

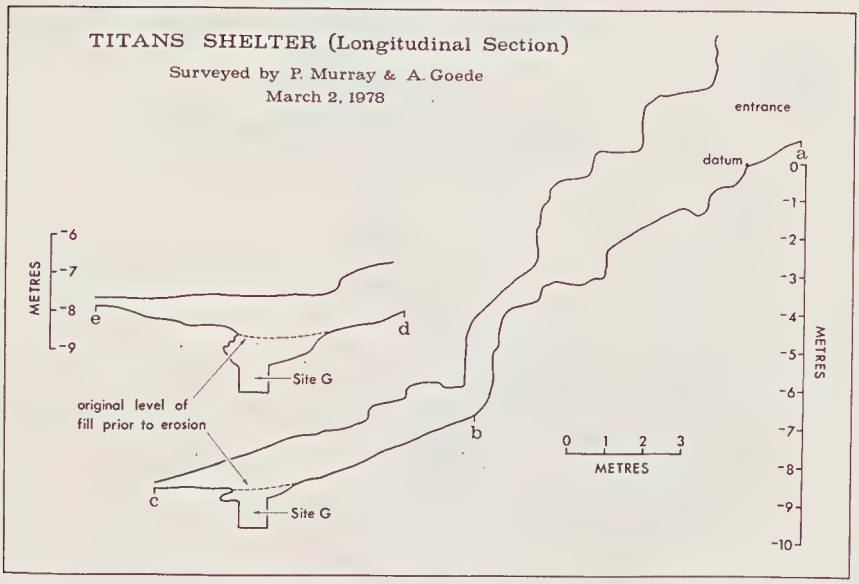


FIG. 3.- Longitudinal section of Titans Shelter.

This chamber is six metres long and up to five metres wide with the floor sloping towards a low point near the north-western extremity. Here, prior to excavation of site G, a circular pit approximately one metre deep and with a maximum diameter of 60 cm had been eroded in the dissected cave fill making up the floor.

At the north-western extremity of the chamber the floor rises again and a flowstone covered slope leads to a low tunnel which soon becomes too tight to allow further exploration. A draught is present possibly indicating another connection with the surface.

EXCAVATION SITES AND ASSOCIATED SEDIMENTS

Three sites were excavated within the cave, two in the entrance chamber and one in the second chamber.

Site E was located below the south-eastern wall of the entrance chamber (figure 2). In the lower wall above the level of the pit and a little to the north-east some bones and bone fragments were exposed in remnant cave fill containing abundant angular limestone fragments. In the upper 20 cm there is a sparse dull yellowish brown (10 YR/5/4) matrix while the lower 20 cm has an openwork texture. The rock fragments generally range from a few mm to 10 cm in diameter with a modal range of 2-4 cm. Occasional larger fragments up to 30 cm are present. This site is referred to as Site E (wall) in figure 2. Site E was selected because of its proximity to this wall exposure and also because it was one of the few areas in the entrance chamber where large blocks of limestone were absent from the surface. Excavation of a one metre square area on this sloping site revealed a thin uncompacted surface layer of dull

PLATE 1 (top).- View of limestone hill with entrance to Titans Shelter visible below crest.
PLATE 2.- Entrance to Titans Shelter.
PLATE 3 (bottom).- Seiving for bone fragments outside the cave entrance.

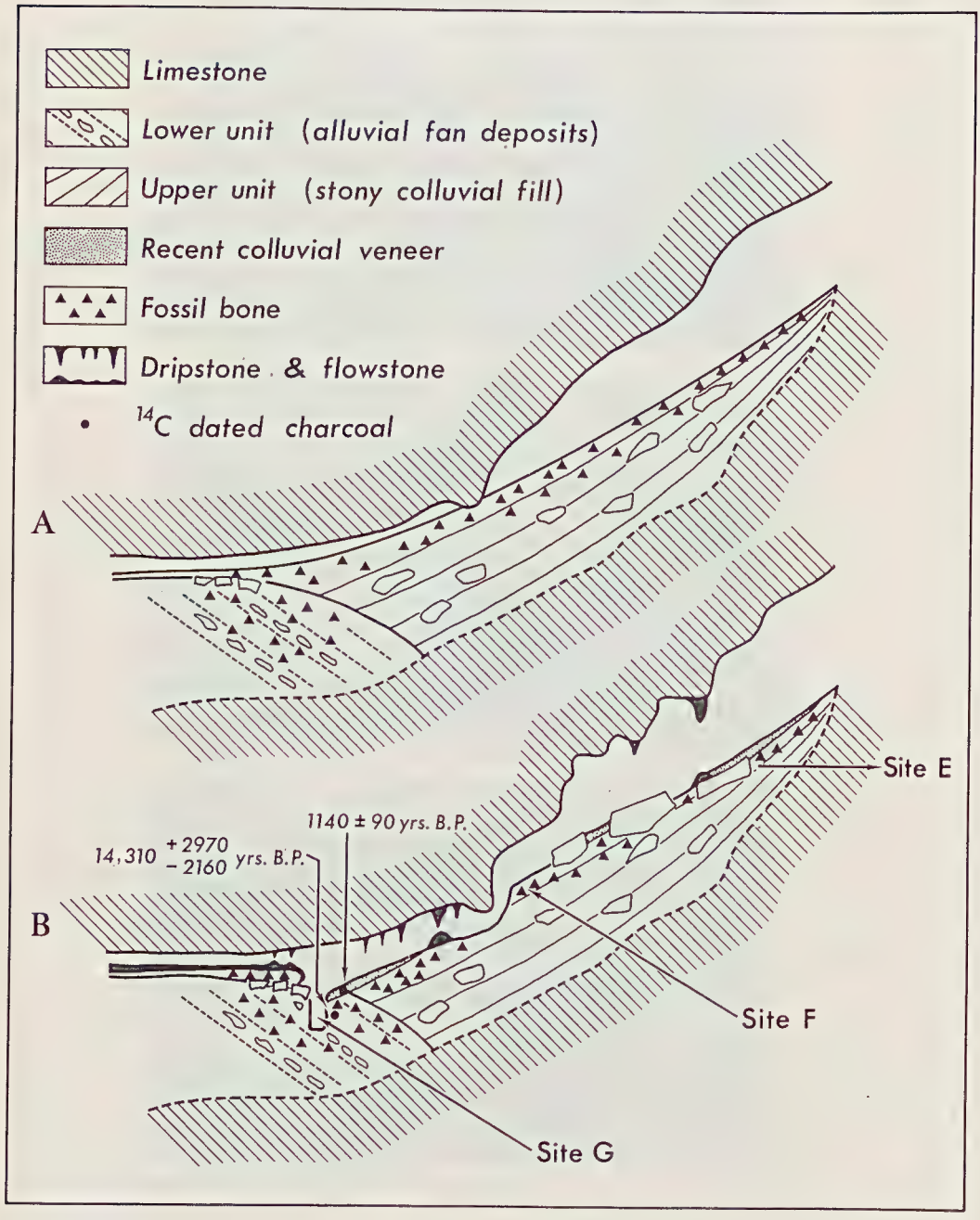


FIG. 4.- Diagrammatic evolutionary sequence of depositional and erosional phases. A, end of Pleistocene. B, present day.

yellowish brown (10 YR/5/3) stony earth thickening downslope and locally containing numerous small bones. There was a steeply dipping contact with marked erosional unconformity between it and the underlying sediments. These sediments form a continuous sediment body with the E wall sediments but are stratigraphically lower in the sequence. They consist of a loosely packed rock rubble in a partial matrix of bright brown (7.5 YR/5/6) earth. Voids are common and there is abundant evidence of subsequent deposition of spongy calcium carbonate by percolating water. The stone size tends to increase towards the base of the exposure with many fragments from 5 to 20 cm in diameter.

The sediments contained a number of bone fragments, many of them broken. A single fragment of angular grey quartzite was also discovered (dimensions 49.0 x 56.5 mm). This represents the only piece of non-limestone rock found so far in any of the sediments examined in this cave. Although it is tempting to suggest that it was brought to the cave by man it shows no clear evidence of being an artifact. Excavation of site E was abandoned because of the decreasing bone content with depth and increasing problems with large blocks of roof fall.

Site F consists of a remnant of undissected cave fill preserved against the west wall of the entrance chamber near its lowest point (figures 2 and 4). The deposit consists of an accumulation of limestone fragments ranging in size from angular chips a few mm in diameter to fragments up to 15 cm. The modal size range is approximately 1 to 3 cm. In the upper part of the deposit the fragments are contained in a sparse matrix of reddish brown (5 YR/4/6) clay rich sediment but downwards this grades into an openwork accumulation of angular rock fragments frequently coated with spongy calcium carbonate. The exposure shows at least one metre of sediments of which the top 40 cm are rich in fossil bone and have been excavated. Cementation of the deposit is quite variable ranging from strongly cemented to loose and friable.

Site G is located at the lowest point of the cave and has been briefly described in an earlier paper (Goede, Murray and Harmon 1978). Prior to excavation it consisted of a circular erosion pit approximately one metre deep and with a maximum diameter of 60 cm. The exposure of numerous small bone fragments in the sides of the pit prompted selection of the site for excavation. The pit was itself located in the floor of a larger erosional depression the outline of which is clearly shown in figure 2 as a vertical change in floor level. The sedimentary sequence is partially capped by flowstone deposition from water entering the chamber from the north-west (figures 2 and 4).

The upper unit of the underlying sediments is up to 70 cm thick and is best exposed to the west of the site and above the level at which excavation started. The deposit is strongly cemented and consists of limestone fragments from a few mm to 30 cm in diameter with a modal size range from 2 to 10 cm. There is a sparse matrix of poorly-sorted, dull yellow orange (10 YR/6/4) sediments containing significant amounts of fragmented bone. There is an erosional gap at floor level which separates it from the lower unit exposed in the pit.

To the north of the pit the upper unit rests on the lower one but the two are separated by a layer of limestone slabs approximately 30 cm thick produced by roof fall. The upper unit is poorly exposed here due partly to heavy post depositional incrustation of carbonate and partly to subsequent excavation of animal burrows below the flowstone cap. There appears to be a higher proportion of matrix, yellowish brown (10 YR/5/6) in colour, and also containing bone fragments.

The overall slope of the surface of the upper unit indicates that the sediments originated from the present entrance. This unit represents the last major phase of clastic deposition in the cave and the sediments are similar to those exposed at sites E and F with which they are correlated. The erosional depression around site G

has been excavated largely within the upper unit, the material having apparently been removed through the erosional gap between it and the lower unit.

The lower unit consists of at least 90 cm of brown to bright brown (7.5 YR/4/6 to 5/6) cave earth with a significantly lower stone content than the upper unit. This material was originally exposed in the walls of the pit which was excavated to form a flat-floored rectangular excavation with dimensions of 75 x 120 cm and with depth varying from 75 to 95 cm due to the slope of the floor. The deposit is rich in small bone fragments in a state of preservation varying from very good to soft and crumbly. The nature of the bone fragments, to be discussed later, indicates that the material originated from a carnivore's den (probably *Sarcophilus*).

The sediments show poorly developed bedding dipping towards the south-east with apparent angles of dip of 25°-35°. A similar depositional slope is indicated by a roof fall horizon. In contrast to the overlying bed the sediments have been derived from the constricted passage entering the chamber from the north-west. Their nature indicates deposition by slow moving water in the form of a fan with intermittent roof fall contributing. The sediments are locally penetrated by modern roots several of which had to be cut during excavation.

Charcoal collected from the deposit from the south-eastern wall of the excavation at a depth of between 58 and 75 cm below the surface was carefully inspected for possible modern root contamination and pretreated prior to dating with boiling 2N HCl solution. The age was determined as $14,310 \pm \frac{2970}{2160}$ years BP (GaK-6875).

The sections (figure 4) show that on the north-western side of the pit the older sediments are overlain by a low mound of much more recent reddish brown (5 YR/4/6) sediment which accumulated as a result of animal burrowing (probably by *Vombatus ursinus*) in the upper unit. This is clearly a recent event postdating the dissection of the upper unit.

On the south-eastern side of the pit the sediments of the lower unit are overlain by a thin (< 10 cm) layer of loose charcoal rich sediment which accumulated as a thin mantle after dissection of the older deposits. Charcoal from this layer was pretreated with boiling 2N HCl solution and yielded a late Holocene date of 1140 ± 90 years BP (GaK-6874).

FAUNAL ANALYSIS

Samples of fossil vertebrate remains were recovered from three sites in Titans Shelter. Site E yielded insufficient material for statistical analysis. Sites F and G both contained numerous whole and fragmentary bones in sufficient quantity to permit comparison with other Florentine Valley cave deposits.

Site E: A clear faunal demarcation between Holocene and Pleistocene sediments was apparent in this test excavation. The upper, probably mid to Late Holocene stratum contains only small mammal remains which represent regurgitated predatory bird pellets. The marsupial mouse *(Antechinus swainsoni)* and the long-tailed rat *(Pseudomys higginsi)* are the dominant elements in the deposit. A single canine of a Peramelid (probably *Perameles*) was also recovered.

The lower brown stratum contained *Thylogale billardieri, Macropus rufogriseus* and *Dasyurus viverrinus*.

Site F: A total of 659 specimens of fossil bone was excavated from a small area of less than .5m^2 excavated to an average depth of 25 cm. About two-thirds of these remains were identifiable to genus. Nearly 10 per cent of the sample was composed of

unbroken long bones (plate 4).

The material shows evidence of both pre and post depositional alterations by predators and rodents. Tooth marks attributable to marsupial carnivores appear on four per cent of the specimens (figure 5). Eroded compact bone surfaces suggest that some of the fragments may have passed through the digestive system of a carnivorous animal. These comprise another four per cent of the sample. Six per cent of the remains consist of small fragments of long bones that appear to be the result of chewing. In addition, a few bones (1%) have paired, narrow grooves running perpendicular to the long axis of the bone or crests on bones. These grooves closely approximate the dimensions of the occlusal surfaces of *Mastacomys fuscus* incisors.

PLATE 4.- Sample of bone material collected from Site F.

The broken bone fragments in site F fall primarily into four shape categories: oblique (27%) transverse (35%) longitudinal fractures (27.5%) and spiral fractures (3%). The longitudinal fractures appear to be the result of natural weathering processes. Experiments by Miller (1975) suggest that freezing, thawing and drying of fresh bone results in longitudinal cracks that extend into the medullary cavity. Many of the transverse cracks also appear to be due to postmortem exposure to extremes of atmospheric conditions. Oblique and spiral fractures probably occurred while the bone was relatively fresh. The presence of collagen in the bone facilitates this type of damage when shearing forces are applied or when a bone is struck solidly with a heavy object. In site F this could be due primarily to roof fall and secondarily to the activity of carnivores.

Site F contained seven mammal and one bird species (table 1). The remains of a falcon (*Falco* sp.) and the unusually large number of *Dasyurus viverrinus* remains (120 elements) suggest that owls employed the shelter as a roost. Nineteen very large macropodid elements have been assigned to *Macropus titan*. A single metatarsal IV of *Sthenurus* sp. was also recovered. *Macropus rufogriseus* is the most common species from site F, comprising 44% of identifiable remains. *Thylogale billardieri* and *Macropus titan* remains were less common (respectively 7% and 5%). *Sthenurus* is comparatively rare.

The overall representation of skeletal remains shows an expected predominance of axial elements (18%), poor representation of the cranium (3.1%) and good representation of mandibles (9.1%). Pes elements were greatly over represented in the sample (21%).

FIG. 5.- Drawing of selected fossil remains from sites F and G. A, tibiotarsus of *Falco* sp.; B, tarsometatarsus of *Falco* sp.; C, humerus of *Macropus rufogriseus* showing tooth marks and damage to distal and proximal ends by gnawing; E, mandible of *M. rufogriseus* showing attack by snails; D, upper left canine of *Sarcophilus* sp.; G, left M^3 of *Sthenurus* sp. (occlusal and buccal views); H, I^1 of *?Zygomaturus*; I, metatarsal IV of *Macropus titan* showing marks probably made by a carnivore near distal end and marks made by rodent(s) in the middle of the shaft; J, metatarsal V of *Macropus titan* showing tooth marks near proximal end; K, side view of same.
A, B, C, E, I, J, K; x 0.57.
D, F; x 0.7.
G x 0.86.
H x 0.65.

TABLE 1

SPECIES IDENTIFIED IN TITANS SHELTER

Species	Site F		Site G
	Minimum Number	Total Remains Identified	Minimum Number
Falco sp.	1	10	-
Dasyurus viverrinus	18	120	1
Sarcophilus sp.	-	-	4
Pseudocheirus peregrinus	-	-	2
Vombatus ursinus	-	-	1
Sthenurus	1	1	3
Protemnodon	-	-	2
Macropus titan	4	19	8
Thylogale billardieri	2	29	4
Macropus rufogriseus	5	178	5
?Zygomaturus	-	-	1
Mastacomys fuscus	5	44	4

Site G: This sample primarily consists of small, apparently chewed bone fragments averaging between 2 and 3 cm in length. The vast majority of these fragments are technically unidentifiable, although the limited faunal assemblage present in these sites would allow generic assignment on the basis of element size alone. Identification of species and estimates of minimum numbers of individuals are based entirely on isolated teeth and jaw fragments containing teeth (table 1).

Site G contains more species than Site F, but this is probably due to the much larger sample obtained from this location. The total number of fragments exceeds 5000. A representative sample of site G material consisting of 215 specimens was measured by placing each piece in one of seven two-centimetre categories. This was compared with the Site F sample (figure 6).

In site G the number of fragments in the size categories of between 8 and greater than 12 cm is practically nil. In site F there is at least a small representation in each of these larger categories (figure 6, plates 4 and 5). A χ^2 test suggests that the differences in size distribution of bone fragments at the two sites is highly significant ($\chi^2 = 50.13$, $v = 4$, $p < .001$).

The most likely explanation for the difference in size of fragments is that site G represents water sorted and transported material. It seems very likely that the initial assemblage of fossil material represented only in part at site G is a large deposit. Unfortunately, the passage leading to its probable source is too narrow to negotiate.

PALAEOECOLOGY

The modern Florentine Valley fauna consists of species known to inhabit wet sclerophyll and rainforest biomes throughout Tasmania. Samples of fauna from Late Holocene deposits in the valley contain the remains of *Ornithorhynchus, Tachyglossus, Antechinus swainsoni, Dasyurus maculatus, Sarcophilus harrisii, Thylacinus cynocephalus* (now presumed extinct), *Perameles gunnii, Vombatus ursinus, Potorous tridactylus, Thylogale billardieri, Macropus rufogriseus, Pseudocheirus peregrinus* and *Pseudomys higginsi*. Despite the relatively large samples of fossil material from sites F and G, a substantial number of these species are not represented. Important absences include the tiger cat *(D. maculatus)*, the marsupial mouse *(Antechinus swainsoni)*, the velvet

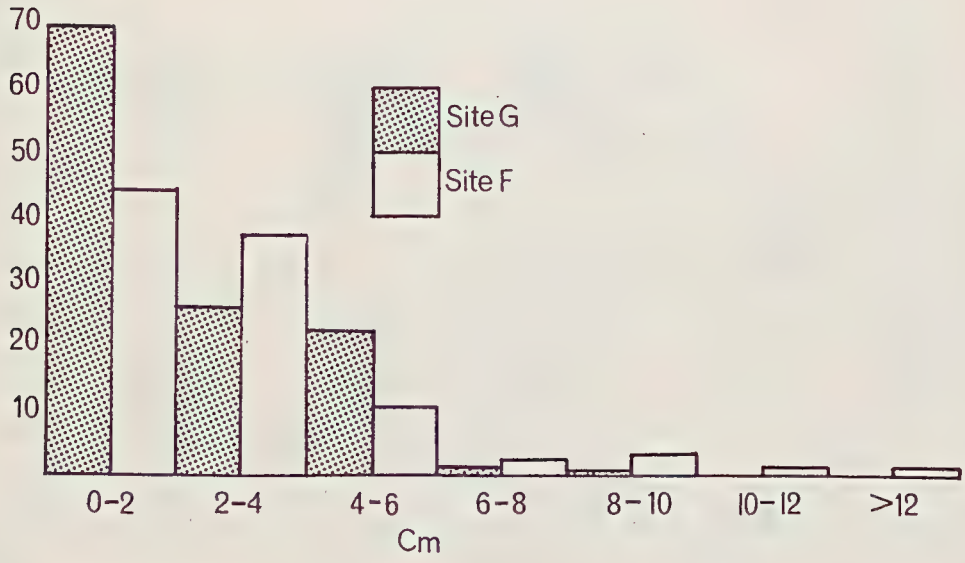


FIG. 6.- Size distribution of bone fragments for sites G (n = 215), and site F (n = 659).

PLATE 5.- Sample of bone material collected from Site G.

furred rat *(R. lutreolus)* and the potoroo *(Potorous tridactylus)*. These mammals are typical fern gully and rainforest edge species. However, certain constituents of the fossil fauna suggest the presence of some type of arborescent vegetation and/or scrub, particularly *Pseudocheirus*, *Sthenurus* and *Thylogale*. The large kangaroo, *M. titan* was probably similar to the modern grey kangaroo in preferring open sclerophyll and woodland savanna habitat. *Mastacomys fuscus* is a relict species in Tasmania. Its distribution during the Late Pleistocene was greatly expanded, while *Rattus lutreolus* and *Pseudomys* spp. appear to have been very rare. *M. fuscus* may have preferred

open sedge and grassland habitats. It is today confined to cool, wet sedgeland and grassland associations. The Titan Shelter assemblage appears to represent an open vegetation type community consisting of some sclerophyll forest elements and some low scrub situated within grasslands.

HISTORY AND AGE OF SEDIMENTATION

The lower unit excavated at site G represents the oldest sediments exposed in the cave. The base is not exposed as it was not possible to deepen the excavation further without digging into collapse material at the base of the pre-existing erosion pit. Unlike the upper unit the provenance of the sediments is from the north-westerly trending passage that continues on from the second chamber. The nature and bedding of the material indicates accumulation by running water in a low energy environment contemporaneous with intermittent roof fall. A very short distance of transport is suggested by the nature of the bone content.

Extinct fauna is represented throughout the excavated depth. Charcoal is not common and at only one place occurred in sufficient quantity to permit C14 dating ($14{,}310\ ^{+2970}_{-2160}$ years BP). The large standard error is due to the small size of the sample. The date indicates a late Pleistocene age. This date has been quoted by Goede, Murray and Harmon (1978) as evidence of Late Pleistocene survival of megafauna in the Florentine Valley. However, it cannot be regarded as conclusive evidence. Since the bone content has been reworked the possibility exists that the bone is significantly older than the charcoal with which it is associated.

The upper unit is exposed in the banks above the level of excavation site G. The upper horizons of the same unit were examined at sites E (wall), E and F while some of the lower horizons are exposed in the squeeze below site F. Beds with limestone fragments in a sparse matrix alternate with layers of open work fragments. Both bone and matrix seem to be concentrated in the upper horizons but bone is relatively abundant only at site E.

The upper unit appears to have accumulated as a result of gravitational movement downslope of material produced by roof fall and physical weathering. The nature of this deposit suggests cold and probably dry conditions during its formation. It is similar in character to the upper unit described from site P in Beginners Luck Cave (Goede and Murray 1977) and the two deposits may be of similar age. The increase in the content of bone and matrix in the upper horizons may reflect a gradual moderation of climatic conditions.

Unfortunately the unit contains no significant amounts of charcoal that would enable it to be dated. There is no evidence of a significant time gap between the accumulation of the upper and lower units. The upper unit is believed to represent the final phase of Pleistocene deposition prior to the climatic warming which led to the invasion of forests at about 11,500 C14 years BP (Macphail 1975).

It is followed by a long period when erosion by seepage water and deposition of calcium carbonate were the dominant processes. Lack of physical weathering and widespread chemical deposition suggest mild and wet climatic conditions which may have persisted through much of the Holocene. Patchy cementation and local spongy carbonate deposition within the late Pleistocene fills probably also occurred during this time.

Following this episode there was very restricted clastic deposition in late Holocene times. This seems to have been due to the activities of birds and burrowing animals and also to occasional disturbance of the forested surface environment by fire. An episode of fire disturbance is dated at 1140 ± 90 years BP.

CONCLUSIONS

An unknown thickness of late Pleistocene deposits partially filled Titans Shelter and can be subdivided into two units. The lower unit was deposited by running water with an admixture of rockfall. The fragmentary bone content represents a late Pleistocene megafauna and suggests surface vegetation conditions rather different from the dense wet sclerophyll forest present in historical times. The C14 date obtained from the unit has been used by Goede, Murray and Harmon (1977) as evidence for the late survival of Pleistocene megafauna in Tasmania but the large standard error of the date combined with the possibility that the bone material may be older than the sediments in which it occurs must throw some doubt on the evidence.

The younger unit indicates cold and dry conditions with evidence of fauna indicated only in the upper horizons. Accumulation may have occurred under conditions of maximum cold during the last glaciation with some amelioration towards the end.

The balance then swung to a dominance of sediment removal by running water and speleothem formation during the wetter and milder conditions of the Holocene. The most recent events are minor erosion and sedimentation due to biological activity in the cave and fire disturbance of the surface environment.

ACKNOWLEDGEMENTS

We are grateful for the financial support received by one of us (A. Goede) from the Australian Research Grants Committee towards the cost of field work and C14 dating of the site. Assistance from the University of Tasmania and the Tasmanian Museum is also acknowledged.

We appreciate the help of Denis Charlesworth in the seiving operations on the site and the cleaning of bone material in the laboratory. Mrs. Kate Morris drafted the maps and diagrams and the manuscript was typed by Terese Flannagan.

REFERENCES

Corbett, K.D., 1963: Geology of the Florentine Valley area. *U. Tasm. unpub. thes.*

Goede, A. and Murray, P., 1977: Pleistocene Man in South Central Tasmania: evidence from a cave site in the Florentine Valley. *Mankind*, 11: 2-10.

_____ and Harmon, R., 1978: Pleistocene Man and megafauna in Tasmania: dated evidence from cave sites. *The Artifact*, 3(3): 139-149.

Macphail, M., 1975: Late Pleistocene environments in Tasmania. *Search*, 6: 295-300.

Miller, G.J., 1975: A study of cuts, grooves and other marks on recent and fossil bone: II Weathering cracks, fractures, splinters and other similar natural phenomena. In Swanson, E. (Ed.): LITHIC TECHNOLOGY. Mouton Publishers, The Hague, 251 p.

Murray, P. and Goede, A. 1977: Pleistocene vertebrate remains from a cave near Montagu, NW Tasmania. *Rec. Q. Vict. Mus.*, 60: 30 p.

STANDARD SOIL COLOR CHART, 1965: Fujihira Industry Co. Ltd., Tokyo.

Papers and Proceedings of the Royal Society of Tasmania, Volume 113, 1979

(ms. received 2.11.1978)

SOME TASMANIAN SPIDERS OF THE FAMILIES OONOPIDAE, ANAPIDAE AND MYSMENIDAE

by V.V. Hickman
Hobart

(with one table and 47 text figures)

ABSTRACT

HICKMAN, V.V., 1979 (20 vii): Some Tasmanian spiders of the families Oonopidae, Anapidae and Mysmenidae. *Pap. Proc. R. Soc. Tasm.*, 113: 53-79. ISSN 0080-4703. 69 Cross Street, New Town, Tasmania, Australia.

A key to the Tasmanian Oonopidae is given and six members of the family described. Of these four are new species, namely *Cornifalx insignis*, *Tasmanoonops fulvus*, *T. magnus* and *T. inornatus*. The first species is made the type of the new genus *Cornifalx*. It is remarkable for the unusual sexual dimorphism exhibited by the male. The hitherto unknown male of *Oonopinus mollipes* Hickman is described for the first time. *Oonops pulcher* Templeton, a well known European oonopid, is recorded from Tasmania for the first time and a brief description of the male given. In the Anapidae two new apneumone species are described and made the types of new genera. The first is *Acrobleps hygrophilus*, which has a palpless female and spins an orb web. The second is *Olgania excavata*, which has a deeply indented abdomen and exhibits extensive sclerotization. The family Mysmenidae is recorded from Australia for the first time and is represented by *Mysmena tasmaniae* sp. n. The species is described and an account of its habits and life-history given.

INTRODUCTION

Some of the spiders described in the present paper form part of a large collection from remote areas in south-western Tasmania. The collection was made during "The Lower Gordon River Scientific Survey" 1976-1978, sponsored by the Hydro-Electric Commission. A debt of gratitude is due to the Commission for providing transport to the areas and for making available at Strathgordon facilities for the preliminary extraction of the material collected.

In the present paper the term "allotype" is applied to a specimen, which is selected as a type and which is opposite in sex to the holotype. The term is used even though the specimen selected may not be a syntype, that is to say, one of the original series collected.

Family OONOPIDAE

The spiders of this family are usually small being about 1.0 - 2.0 mm in length. However, some Tasmanian species exceed 5.0 mm. The carapace is without fovea and radial grooves. Six eyes or less are present. The chelicerae lack lateral condyles, the furrow is oblique and the margins usually without teeth. Some species, however, have teeth on one or both margins. The maxillae are converging and have a scopula and serrula. The labium is free. The female pedipalp usually but not always lacks a claw. The legs have an onychium bearing two claws, each with a double row of pectinations. The abdomen has a pair of lung slits in the normal position and, close behind them, a pair of tracheal spiracles, from which tracheae extend into the cephalothorax. A colulus is present in some species, absent in others.

Tasmanian Oonopid, Anapid and Mysmenid Spiders

Most oonopids are found in moss and leaf litter in rain forests, some occur in grass tussocks and a few in buildings. They do not spin a web but some make short tubular retreats. Their egg-sac is plano-convex and made in the retreat.

Key to Tasmanian Oonopidae

1a. Abdomen above pale grey with a black median mark followed by five black chevrons.....*Cornifalx insignis* gen. et sp. n.
b. Pattern on abdomen otherwise 2
2a. Abdomen above greyish brown with five cream chevrons.....*Oonopinus mollipes* Hickman, 1932
b. Pattern on abdomen otherwise 3
3a. Abdomen above dark brown with three thin pale chevrons .....*Orchestina launcestoniensis* Hickman, 1932
b. Abdomen without pattern 4
4a. Chelicerae without teeth. Four pairs of spines below first tibiae .....*Oonops pulcher* Templeton, 1835
b. Chelicerae with teeth 5
5a. Teeth on both margins of furrow.....*Tasmanoonops alipes* Hickman, 1930
b. Teeth on retromargin only 6
6a. Median eyes in line with front laterals 7
b. Median eyes not in line with front laterals.....*Tasmanoonops fulvus* sp. n.
7a. Tarsal claws with a double row of 18 teeth. Female with hooked spines on front spinnerets.....*Tasmanoonops inornatus* sp. n.
b. Tarsal claws with a double row of 12 teeth. Female without hooked spines on front spinnerets.....*Tasmanoonops magnus* sp. n.

Genus *CORNIFALX* gen. n.

Diagnosis

Anterior margin of carapace of male with a median horn; lateral angles in the form of a rounded lobe. Front of chelicerae in male with a pair of horn-like apophyses. Front of carapace and chelicerae of female normal. Six eyes, median pair contiguous and forming a procurved line with the front laterals. Tarsal claws with a double row of pectinations and a wing-like lobe on the outer side near the base. Six spinnerets, anterior pair without hook-shape spines. Colulus present.

Type of genus: *Cornifalx insignis* sp. n.

Cornifalx insignis gen. et. sp. n.

Male

Measurements in mm:-

Body length	4.66
Carapace length	2.31
Carapace width	1.62
Abdomen length	2.35
Abdomen width	1.54

Leg	Femur	Patella	Tibia	Metatarsus	Tarsus	Total
1	1.90	0.84	1.72	1.75	0.70	6.91
2	2.03	0.91	1.68	1.92	0.70	7.24
3	1.61	0.70	1.26	1.54	0.56	5.67
4	1.90	0.84	1.54	1.85	0.63	6.76
Palp	0.84	0.49	0.66	-	0.84	2.83

Carapace light brown with darker margin, a transverse dark procurved line with forked ends immediately behind head region. Appendages yellowish brown; femora, patellae and tibiae darker distally and at the sides. Sternum light brown with darker margin. Labium dark on each side. Abdomen pale grey with a median longitudinal black mark on front half of dorsum followed by five black chevrons on hinder half and a dark area on each side of spinnerets (fig. 1).

Carapace oval, narrowed in front to 5/8 its maximum width. Anterior margin with a median horn-like projection extending forwards, lateral angles in the form of rounded lobes. Six eyes, each surrounded by a black rim. Ocular area almost as wide as front of carapace, wider than long in ratio 5:2, and wider behind than in front in ratio 10:9. Ratio of eyes ME:ALE:PLE = 11:13:15. ME contiguous, on a transverse line passing between ALE and PLE and separated from ALE by half a diameter and from PLE by twice that distance. Laterals contiguous. Clypeus with a height equal to one diameter of ME.

Chelicerae conical, almost parallel, without lateral condyles, sloping backwards and overhung by clypeus; a large horn-like apophysis projects forwards and upwards from the front of each (fig. 2). Two smaller processes occur near the base of each chelicera and are partly hidden by the overhanging clypeus. Fang well curved. Furrow oblique, two teeth on each margin and a scopula on the promargin. Maxillae almost parallel with serrula on anterior margin and a light scopula on inner angle. Labium wider than long in ratio 11:10 and about 4/7 the length of the maxillae, truncate and slightly notched in front, convex from side to side and clothed with few setae. Sternum shield-shape, rebordered, excavated round base of labium, truncate behind, with a sharp marginal point opposite base of each coxa and a smaller point between bases of adjacent coxae, surface convex, polished, with few setae.

Legs in order of length 2.1.4.3. Trichobothria short, arising from small cups that are difficult to see, two on each tibia and one on the distal half of each metatarsus. Tarsi with an onychium bearing two claws, each with a double row of pectinations. On the outer side each claw has a wing-like lobe (fig. 3). The onychium has two long barbed setae near base of claws and a dense clothing of spatulate hairs on ventral surface. Spines are as follows:- First leg 0. Second leg 0. Third leg. Femur 0. Patella-prolateral 1-1 on apical half. Tibia- prolateral 1-1, ventral 1 at apex. Metatarsus- dorsal 2 apical, prolateral 1 apical, retrolateral 1 apical, ventral 1 apical. Tarsus 0. Fourth leg. Femur 0. Patella 0. Tibia-ventral 2 apical. Metatarsus- dorsal 2 apical, prolateral 1 apical, retrolateral 1 apical, ventral 1 apical. Elsewhere 0.

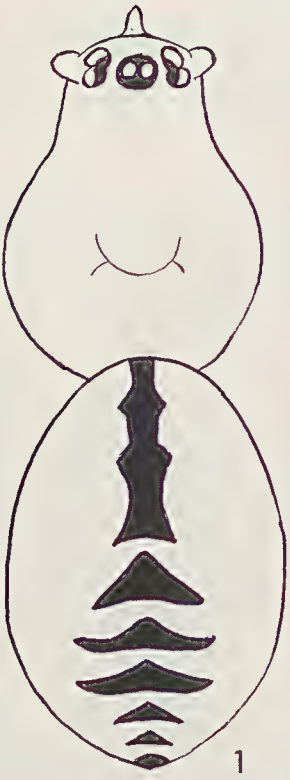
Palpi without spines. One trichobothrium on tibia. Tarsus long and slender. Genital bulb large, pyriform, with four apophyses (fig. 4).

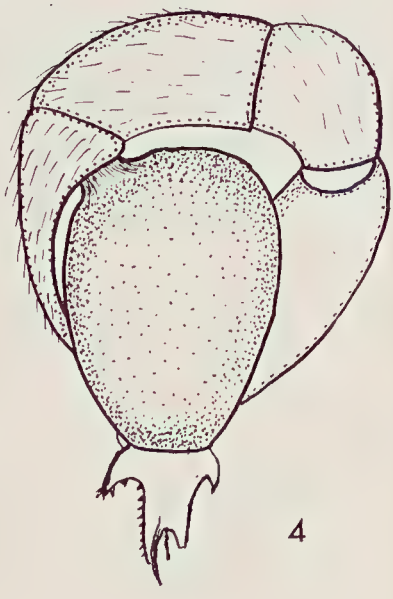
Abdomen ovoid, clothed with short hair. A pair of lung-slits and a pair of tracheal spiracles in the usual positions near the epigastric furrow. Six spinnerets and a colulus present.

Female

Measurements in mm.

Body length	5.71
Carapace length	2.35
Carapace width	1.61
Abdomen length	3.36
Abdomen width	2.10





FIGS 1-4.- *Cornifalx insignis* sp. n. Male: 1-dorsal view of body, 2-eyes and chelicerae from front, 3-tarsal claws, 4-left palp.

Leg	Femur	Patella	Tibia	Metatarsus	Tarsus	Total
1	2.93	0.98	1.61	1.82	0.77	8.11
2	2.10	0.91	1.61	1.92	0.77	7.31
3	1.68	0.70	1.15	1.47	0.63	5.63
4	2.38	0.91	1.54	1.96	0.84	7.63
Palp	0.70	0.49	0.49	-	0.98	2.66

Colour and markings as in male, but in some specimens the posterior cephalic region is darker. Carapace rounded in front without the median horn and lateral lobes of male. Ocular area 4/5 width of carapace in front. Ratio of eyes ME:ALE:PLE = 11:12:11.

Chelicerae conical, vertical, slightly geniculate and constricted at the base but without the horns and basal processes of the male. Two teeth on each side of furrow. Maxillae, labium and sternum as in male. Palpi without claw. Legs in order of length 1.4.2.3. Spines and trichobothria as in male. On ventral side of abdomen there is no distinct epigynum, but a transverse sclerotized bar occurs at the middle of the epigastric furrow in front of the genital aperture. Anterior spinnerets larger than the others and without hook-shaped spines. Colulus conical with a group of about ten setae near apex.

Type locality: Southwestern Tasmania, 145° 53' E, 42° 38' S, 1 ♂ (holotype) from leaf litter in rain-forest 5/1/1978 (L. Hill *et al.*); 145° 46.5' E, 42° 31' S, 1 ♂ (paratype) from moss 9/1/1978 (L. Hill *et al.*); 145° 50' E, 42° 51' S, 1 ♀ (allotype) from moss 16/2/1976 (C. Howard *et al.*); 145° 46' E, 42° 31' S, 3 ♀♀ (paratypes) from leaf litter 19/1/1978 (C. Howard).

Other localities: Western Creek, Tasmania, 1♀ from under fallen log 31/1/1930 (V.V. Hickman); Betts Vale, Mount Wellington, 1 juvenile from moss 7/7/1960 (V.V. Hickman); various localities in southwestern Tasmania, 1♂, 7♀♀, 5 juveniles collected during Jan., Feb. and Mch. 1976/1978 (C. Howard and L. Hill).

Genus *OONOPINUS* Simon, 1893

Oonopinus mollipes Hickman, 1932

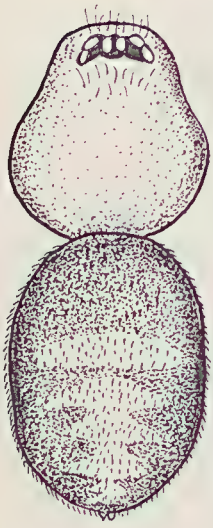
The original description of this species was based on a female from Launceston, the male being unknown at the time. Some years later two males were found at East Risdon, and the following description is therefore given.

Male

Measurements in mm:-

Body length	1.82
Carapace length	0.77
Carapace width	0.62
Abdomen length	1.05
Abdomen width	0.67

Leg	Femur	Patella	Tibia	Metatarsus	Tarsus	Total
1	0.67	0.26	0.56	0.49	0.32	2.30
2	0.63	0.25	0.53	0.48	0.31	2.20
3	0.43	0.21	0.35	0.39	0.21	1.59
4	0.56	0.21	0.42	0.48	0.21	1.88
Palp	0.22	0.15	0.14	-	0.33	0.84

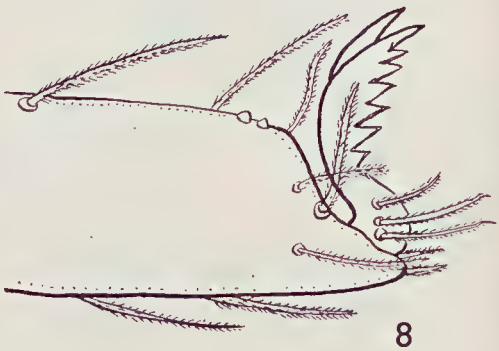


5

9

7

6



8

FIGS 5-9.- *Oonopinus mollipes* Hickman. Male: 5-dorsal view of body, 6-eyes, 7-prolateral side of left chelicera, 8-tarsal claws, 9-right palp.

Cephalothorax dark brown; appendages and sternum light brown, dorsum of abdomen brownish grey with five cream-coloured chevrons on posterior two thirds (fig. 5), venter pale yellow. Carapace oval, narrowed in front to 5/11 of its maximum width, sides granular, a few barbed hairs in front of and behind ocular area. Six eyes (fig. 6) about equal in size and surrounded by black rings. Ocular area 4/5 the width of the cephalic region in front, and wider than long in ratio 17:9. Median eyes contiguous, almost touching ALE in front, but separated from PLE by 3/4 of their long diameter. Height of clypeus equal to 6/5 long diameter of median eyes. Chelicerae

(fig. 7) conical, vertical, 0.37 mm long and 0.14 mm in greatest width, without lateral condyles, surface granular and clothed with a few long hairs; furrow oblique, margins without teeth, basal end with a large tubercle, which is slightly bifid. In front of promargin is a row of about six spinous setae, each accompanied by a barbed hair. At base of fang is a long flagelliform barbed hair. Maxillae narrow, slightly converging, provided with serrula and scopula. Labium triangular, truncated and notched in front, wider than long and about half the length of the maxillae. Sternum broadly oval, convex, truncate behind separating fourth coxae by 3/2 of their width, margin rebordered, laterally the surface is furnished with a few hairs that point inwards.

Legs in order of length 4.1.2.3., clothed with barbed hairs but without spines, two trichobothria on each tibia and one on each metatarsus near apex. Tarsus with a group of small sensory tubercles at distal end; claws carried on an onychium, each with a double row of about six teeth (fig. 8).

Palpi clothed with barbed hairs, two trichobothria on tibiae, spines lacking. Genital bulb large and pyriform; apex widened and forming two projections of unequal length. From the shorter projection a long black spiniform embolus extends (fig. 9).

Abdomen ovoid, nearly twice as long as wide, clothed with barbed hairs. Six spinnerets. Colulus lacking. A pair of lung-slits and a pair of tracheal spiracles in the normal position.

Locality: East Risdon Tasmania, 1 ♂ (allotype), 2 ♀♀ from grass tussocks 19/5/1937; 1 ♂, 4 ♀♀ 23/9/1947 (V.V. Hickman).

Other localities: Liffey Falls, Tasmania, 1 ♂ juvenile from moss 14/5/1953 (V.V. Hickman); southwestern Tasmania, 145° 53' E, 42° 48' S, 1 ♀ from moss 1/3/1977 (L. Hill *et al.*).

Genus *OONOPS* Templeton, 1835

Oonops pulcher Templeton, 1835

This species is a well-known European spider with a wide distribution. It has probably been introduced into Tasmania and is here recorded for the first time. The following brief description should enable the species to be identified.

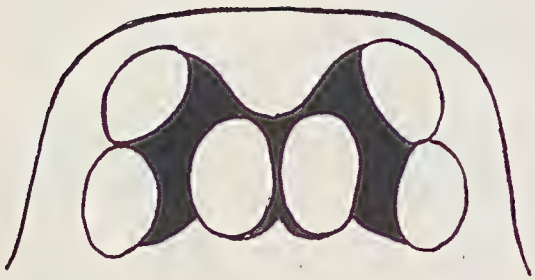
Male

Measurements in mm:-

Body length	1.19
Carapace length	0.56
Carapace width	0.42
Abdomen length	0.63
Abdomen width	0.32

Leg	Femur	Patella	Tibia	Metatarsus	Tarsus	Total
1	0.53	0.22	0.47	0.36	0.25	1.83
2	0.55	0.23	0.53	0.47	0.25	2.03
3	0.42	0.21	0.34	0.34	0.18	1.49
4	0.60	0.24	0.52	0.47	0.23	2.06
Palp	0.18	0.12	0.14	-	0.12	0.56

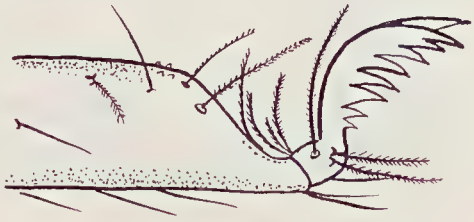
Colour of body and appendages light red. Carapace wide and convex, highest part slightly behind middle. Six eyes (fig. 10). Ocular area wider than long in ratio 13:8.



10

11

13



12

FIGS 10-13.- *Oonops pulcher* Templeton. Male: 10-eyes, 11-prolateral side of right chelicera, 12-tarsal claws, 13-right palp.

Eyes about equal in size, median pair contiguous, laterals also contiguous. Viewed from above the medians and front laterals form a procurved row. Chelicerae (fig. 11) conical, vertical, without lateral condyles, furrow oblique and without teeth on both margins. In front of promargin is a row of about seven spine-like setae accompanied by barbed hairs. At base of fang a long flagelliform barbed hair. Maxillae converging, with a scopula at apex and along distal half of inner margin, a serrula on apical third of outer margin. Labium wider than long and about half the length of maxillae. Sternum shield-shape, broadly rounded posteriorly and widely

separating fourth coxae. Legs in order of length 4.2.1.3., lightly clothed with long hairs; spines present on all tibiae and metatarsi, there being four pairs below first tibiae. Two trichobothria on each tibia and one near apex of each metatarsus. Tarsi with an onychium bearing two claws, each with a double row of about six teeth, those in the outer row being larger than those in the inner row. Two long curved barbed hairs at base of claws and three at base of onychium (fig. 12).

Palpi lightly clothed with long hairs, two erect spines below femur, two trichobothria on tibia. Genital bulb pyriform, with a long slender process projecting from the apex (fig. 13). Near the base of the process is a group of minute tubercles. At the side of the distal part of the bulb is a stout recumbent spine and to one side of the spine a group of minute thorn-like processes.

Abdomen about twice as long as wide, clothed with barbed hairs. Six spinnerets. Colulus lacking.

Locality: Launceston, Tasmania. 1 ♂ found under a board in a poultry enclosure 29/4/1928 (V.V. Hickman).

Genus *TASMANOONOPS* Hickman, 1930

Tasmanoonops fulvus sp. n.

Male

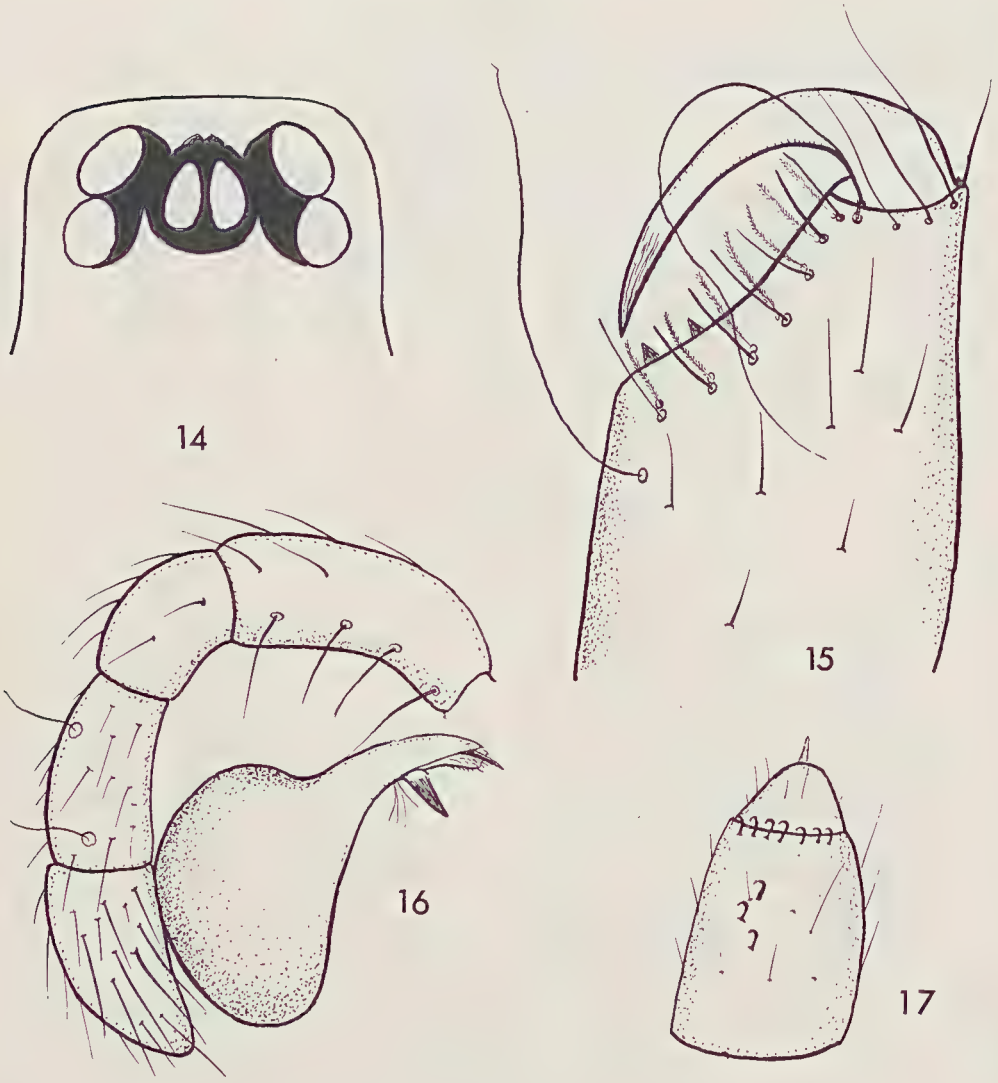
Measurements in mm:-

Body length	2.03
Carapace length	1.03
Carapace width	0.74
Abdomen length	1.00
Abdomen width	0.56

Leg	Femur	Patella	Tibia	Metatarsus	Tarsus	Total
1	0.75	0.31	0.57	0.55	0.34	2.52
2	0.68	0.27	0.52	0.48	0.33	2.28
3	0.66	0.23	0.45	0.44	0.30	2.08
4	0.82	0.27	0.61	0.75	0.34	2.79
Palp	0.28	0.17	0.19	-	0.22	0.86

Cephalothorax and appendages yellowish brown; abdomen grey without pattern. Carapace oval, narrowed in front to half its maximum width, surface smooth, lateral margins rebordered, a few hairs on cephalic region. Six eyes in a close group (fig. 14), each eye surrounded by a black ring. Ocular area 5/6 of width of carapace in front and twice as wide as long. Eyes about equal in size; median eyes on a transverse line passing between lateral eyes of each side. Chelicerae narrow, conical, vertical, without lateral condyles; furrow oblique with two teeth on retromargin; a row of erect spines accompanied by barbed hairs in front of promargin. Near base of fang is a very long flagelliform barbed hair and also a very long hair near the proximal end of promargin (fig. 15). No teeth on the promargin. Maxillae almost parallel and provided with serrula and scopula. Labium longer than wide, truncate in front and slightly more than half as long as maxillae. Sternum shield-shape, convex, polished, rebordered and ending in a rounded point between the fourth coxae, which are well separated.

Legs in order of length 4.1.2.3. Two trichobothria on each tibia and one on the distal half of each metatarsus. Two tarsal claws, carried on an onychium and with a double row of about seven teeth. Spines as follows:- First leg 0. Second leg 0.



FIGS 14-17.- *Tasmanoonops fulvus* sp. n. Male: 14-eyes, 15-prolateral side of right chelicera, 16-right palp. Female: 17-ventral side of front spinneret.

Third leg. Femur 0, patella 0. Tibia- dorsal 0, prolateral 1-1, retrolateral 1-1, ventral 1-2 apical. Metatarsus- dorsal 0, prolateral 1, retrolateral 1, ventral 1-2 apical. Tarsus 0. Fourth leg. Femur 0. Patella 0. Tibia- dorsal 0, prolateral 1-1, retrolateral 1-1-1, ventral 1-1-2 apical. Metatarsus as for tibia. Tarsus 0.

Palpi (fig. 16) without spines but with some coarse setae above tibia and tarsus. Two trichobothria on tibia. Genital bulb pyriform with a strong tooth-like apophysis near distal end. At the base of the apophysis is a group of four setae. The apical part of the bulb encloses a sharp black spine and a small barbed ligule.

Abdomen ovoid, clothed with recumbent hairs. Venter with a pair of lung-slits and a pair of tracheal spiracles in the normal position. Six spinnerets and a colulus present. Colulus furnished with setae.

Female

Measurements in mm:-

Body length	2.46
Carapace length	0.99
Carapace width	0.77
Abdomen length	1.47
Abdomen width	0.92

Leg	Femur	Patella	Tibia	Metatarsus	Tarsus	Total
1	0.70	0.33	0.54	0.52	0.30	2.39
2	0.70	0.33	0.53	0.49	0.29	2.34
3	0.63	0.21	0.42	0.49	0.28	2.03
4	0.78	0.28	0.59	0.73	0.33	2.74
Palp	0.28	0.14	0.20	-	0.29	0.91

Female resembles male in most features. Chelicerae are slightly stouter but have the same dentition. Palpi have two trichobothria on tibia as in male; a claw is absent but the tarsus has a number of coarse barbed setae at the apex. The anterior spinnerets differ from those of the male in having a number of hook-shaped spines on the ventral surface (fig. 17).

Type locality: southwestern Tasmania, 145° 50' E, 42° 56' S, 1 ♂ (holotype) from leaf litter 18/2/1977 (C. Howard *et al.*); 145°42' E, 42° 35' S, 1 ♀ (allotype) from moss 31/1/1976 (C. Howard *et al.*).

Other localities: Near southern end of Lake St. Clair, 1 ♂, 8 ♀♀ from moss 7/2/1945 (V.V. Hickman); Tarraleah, 1 ♂, 1 ♀ from moss 16/4/1959 (V.V. Hickman); South side of Lyell Highway, east King William Saddle 3 ♂♂, 1 ♀ from litter under *Nothofagus* trees 19/3/1974 (J.L. Hickman); various localities in southwestern Tasmania, 3 ♂♂, 7 ♀♀ from moss and litter in rain-forest areas during January and February 1976-1977 (C. Howard, L. Hill *et al.*).

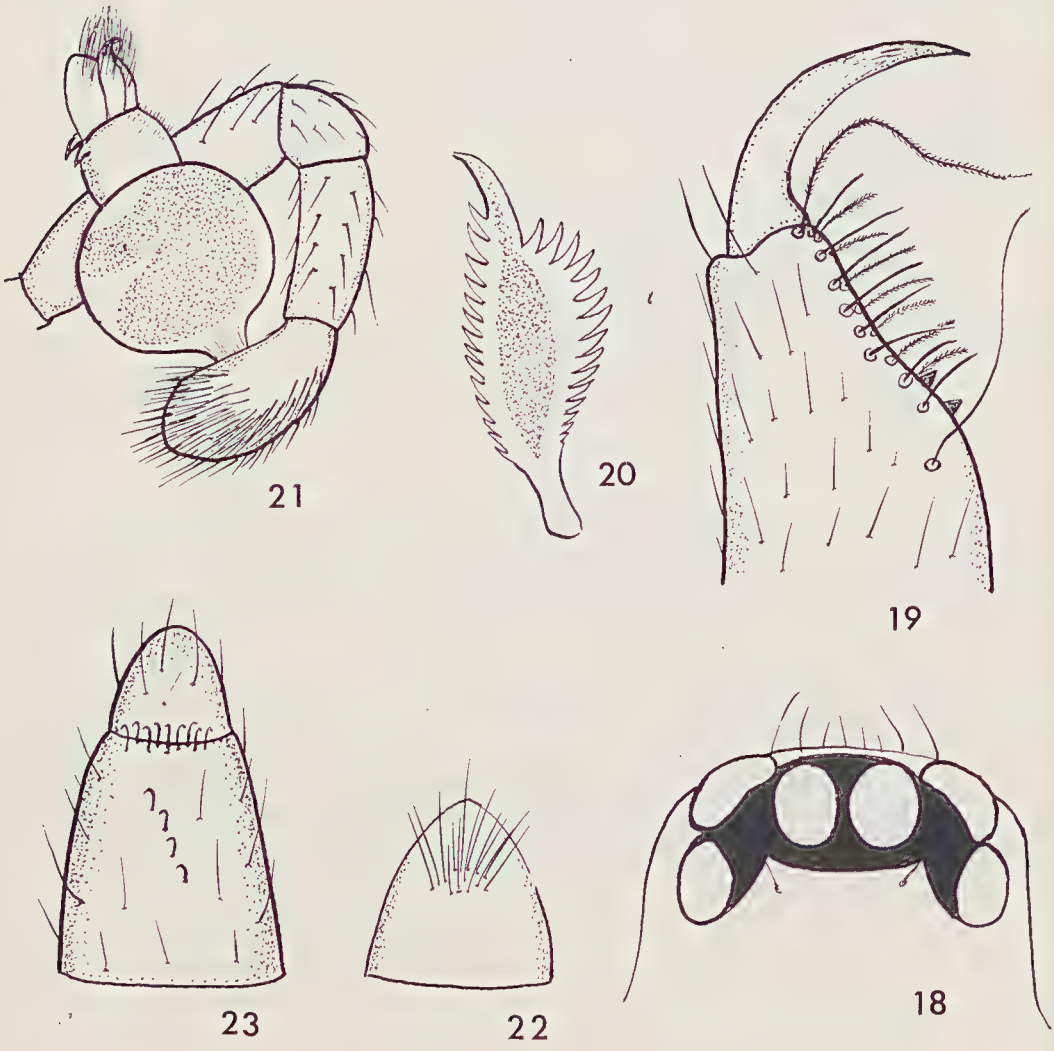
Tasmanoonops inornatus sp. n.

Male

Measurements in mm:-

Body length	3.00
Carapace length	1.42
Carapace width	1.12
Abdomen length	1.62
Abdomen width	0.87

Leg	Femur	Patella	Tibia	Metatarsus	Tarsus	Total
1	1.50	0.62	1.25	1.30	0.55	5.22
2	1.47	0.52	1.27	1.28	0.52	5.06
3	1.25	0.52	0.98	1.10	0.50	4.35
4	1.62	0.55	1.05	1.60	0.55	5.37
Palp	0.55	0.25	0.27	-	0.50	1.57



FIGS 18-23.- *Tasmanoonops inornatus* sp. n. Male: 18-eyes, 19-prolateral side of left chelicera, 20-ventral side of claw, 21-left palp, 22-colulus. Female: 23-ventral side of front spinneret.

Cephalothorax and appendages brownish yellow; abdomen grey without pattern. Carapace oval, narrowed in front to 1/6 its greatest width, lateral margins rebordered, surface clothed with fine recumbent hairs, several bristles in a median row on cephalic part. No fovea or radial grooves. Six eyes (fig. 18) of about equal size. Ocular area the full width of front of carapace and twice as wide as long. Viewed

from above ME in line with ALE and almost touching ALE in front, but separated from PLE by half their diameter. ALE and PLE contiguous. Height of clypeus equal to half the diameter of ME. About 12 setae in front of eyes. Chelicerae conical, vertical, parallel, without lateral condyles and three times as long as wide; furrow oblique, two teeth on retromargin, none on promargin. In front of promargin a row of erect spines accompanied by barbed hairs. Near base of fang a very long flagelliform barbed hair and also a long hair near proximal end of furrow (fig. 19). Maxillae almost parallel and provided with scopula and serrula. Labium wider than long and about half the length of maxillae, truncate and notched in front. Sternum shield-shape, convex, truncate in front and pointed behind, rebordered, clothed on each side with a few hairs and on the posterior point with ten larger setae, margin produced into a sharp point opposite base of each coxa.

Legs in order of length 4.1.2.3.; clothed with short hairs, two trichobothria on each tibia and one near the apex of each metatarsus. A group of three small sensory tubercles near apex of each tarsus. The two tarsal claws are carried on an onychium, each has a double row of about 18 teeth and on the outer side a wing-like lobe (fig. 20). The onychium is provided below with a number of spatulate hairs. Two large barbed setae occur near the base of the claws and three smaller ones in a transverse row at the base of the onychium. Spines are as follows:- First leg 0. Second leg 0. Third leg. Femur 0. Patella 0. Tibia - dorsal 0, prolateral 1-1-1, retrolateral 1-1, ventral 2 apical. Metatarsus - dorsal 0, prolateral 1-1, retrolateral 1-1, ventral 2-1 apical. Tarsus 0. Fourth leg. Femur 0. Patella 0. Tibia - dorsal 0, prolateral 1, retrolateral 1-1-1, ventral 2 apical. Metatarsus - dorsal 0, prolateral 1-1-1-1, retrolateral 1-1, ventral 1 apical. Tarsus 0.

Palpi (fig. 21) lightly clothed with hairs but more densely on tarsus than elsewhere. Two trichobothria on tibia. Spines absent. Genital bulb pyriform but constricted to form a large globular basal division and a smaller apical part. The latter is partly clothed with very short hairs. At the distal end is a wide ligule densely covered with fine hairs; at the front of the ligule a spine-like process with a hook-shaped end. On the other side of the distal end are two thorn-like projections.

Abdomen ovoid, almost twice as long as wide, clothed with short hairs, a pair of lung-slits and a pair of tracheal spiracles in the usual position on the venter. Six spinnerets and a colulus present, the colulus with about ten setae (fig. 22).

Female

Measurements in mm:-

Body length	2.66
Carapace length	1.12
Caparace width	0.70
Abdomen length	1.54
Abdomen width	0.84

Leg	Femur	Patella	Tibia	Metatarsus	Tarsus	Total
1	0.82	0.41	0.62	0.62	0.37	2.84
2	0.81	0.41	0.59	0.60	0.37	2.78
3	0.55	0.34	0.44	0.53	0.30	2.16
4	0.89	0.40	0.70	0.78	0.34	3.11
Palp	0.30	0.20	0.19	-	0.34	1.03

Female resembles the male in colour and general features. Palpi lack a claw, but the tarsus ends in a sharp point, coarse spine-like setae and barbed hairs. Anterior spinnerets with a number of hook-shaped spines on the ventral surface and some forming a double row at the distal end of the first segment (fig. 23). Colulus as in male.

Type locality: Southwestern Tasmania, 145° 53' E, 42° 48' S, 1 ♂ (holotype) from leaf litter 1/3/1977 (L. Hill *et al.*); 145° 45.5' E, 42° 31' S, 1 ♀ (allotype) from leaf litter 19/1/1978; 145° 42' E, 42° 35' S, 1 ♂ (paratype) from moss 31/1/1976 and 1 ♀ (paratype) from leaf litter 29/1/1976; 145° 43' E, 42° 34' S, 1 ♀ (paratype) from leaf litter 2/2/1976 (C. Howard *et al.*).

Tasmanoonops magnus sp. n.

Male

Measurements in mm:-

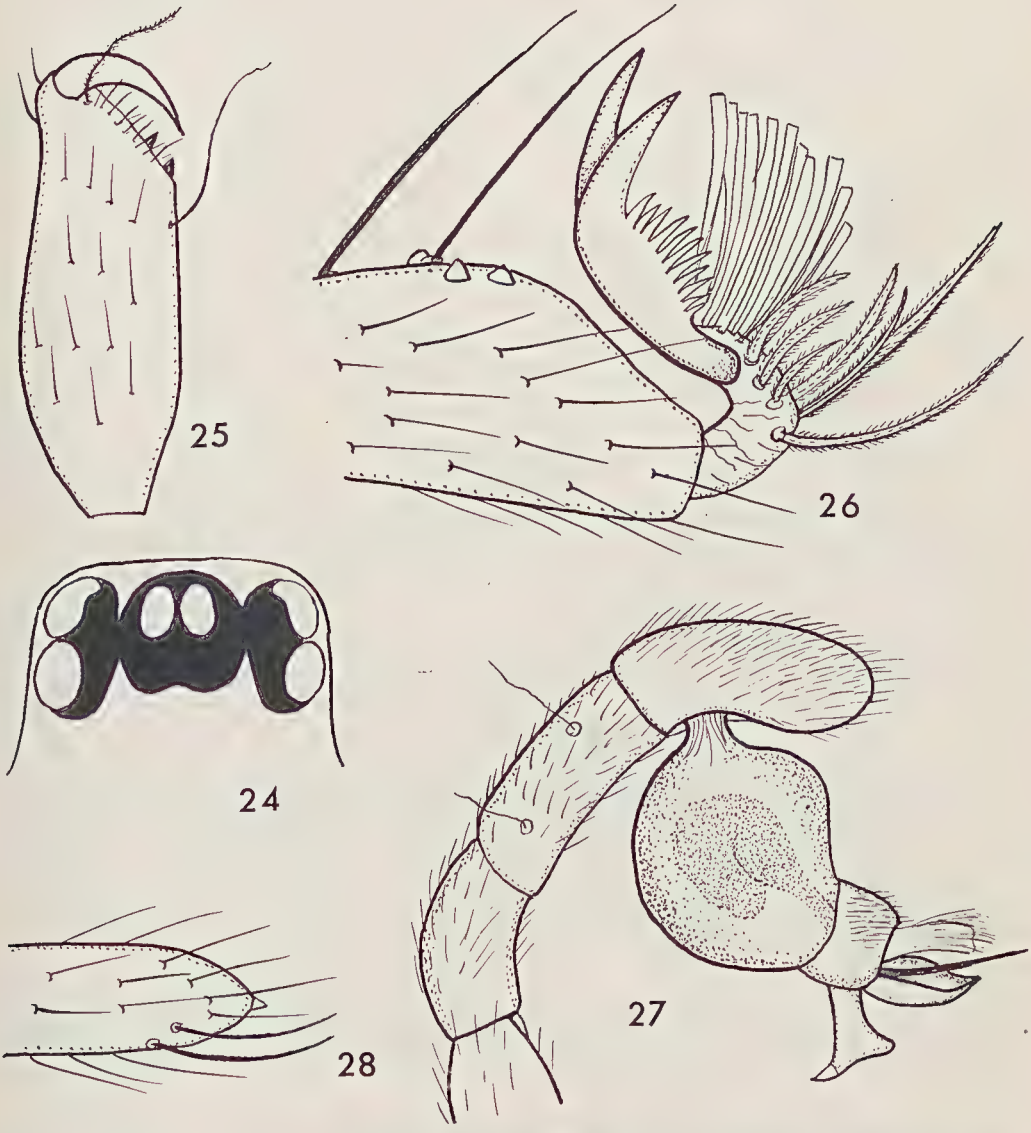
Body length	4.17
Carapace length	1.82
Carapace width	1.37
Abdomen length	2.34
Abdomen width	1.26

Leg	Femur	Patella	Tibia	Metatarsus	Tarsus	Total
1	2.00	0.86	1.83	1.94	0.80	7.43
2	2.17	0.86	1.88	2.00	0.80	7.71
3	1.77	0.63	1.31	1.60	0.57	5.88
4	2.28	0.68	1.88	2.17	0.63	7.64
Palp	0.57	0.34	0.40	-	0.46	1.77

Cephalothorax and appendages light brown, sternum darker round the margin. Abdomen brownish grey. Carapace oval, convex, narrowed in front to half its maximum width, lightly clothed with short recumbent hairs pointing forward, no fovea or radial grooves. Six eyes (fig. 24). Ocular area as wide as front of cephalic part and twice as wide as long. Eyes about equal in size. Viewed from above ME in line with ALE. ME contiguous, separated from ALE by 5/7 and from PLE by 9/7 of their diameter. Lateral eyes contiguous. All eyes surrounded by black rings. Chelicerae 0.86 mm long and 0.20 mm wide, vertical, without lateral condyles, furrow oblique, retromargin with two teeth, promargin without teeth (fig. 25). In front of promargin a row of about eleven spine-like setae, most of them accompanied by a barbed hair. At distal end of row near base of fang a long flagelliform barbed seta and a second long seta near the proximal end of row. Maxillae almost parallel with a tuft of long hairs at apex and a scopula along inner margin; a serrula is present on antero-lateral side. Labium wider than long, slightly more than half the length of maxillae, convex from side to side, widely truncate in front. Sternum shield shape, convex, excavated round bases of labium and maxillae, pointed behind, margin rebordered and with a large point opposite base of each coxa, a smaller point between bases of adjacent coxae.

Legs in order of length 4.2.1.3. First and second legs almost equal in length. Two trichobothria on each tibia and one near the apex of each metatarsus. Tarsus with an onychium bearing two claws, each with a double row of about twelve teeth and a wing-like lobe on the outer side. Onychium with a large number of spatulate hair below and a long barbed seta on each side near base of claws. Near the apex of tarsus at the base of a long seta are two sensory tubercles (fig. 26). Spines as follows:- First leg 0. Second leg 0. Third leg. Femur 0. Patella 0. Tibia - dorsal 0, prolateral 1-1-1, retrolateral 0, ventral 1. Metatarsus - dorsal 0, prolateral 1 apical, retrolateral 0, ventral 1 apical. Tarsus 0. Fourth leg. Femur 0. Patella 0. Tibia - dorsal 0, prolateral 1 apical, ventral 0. Metatarsus - dorsal 0, prolateral 1-1-1, retrolateral 1-1-1, ventral 0-1-1. Tarsus 0.

Palpi (fig. 27) without spines, distal half of tarsus densely clothed with hairs, two trichobothria on tibia. Genital bulb pyriform with a slight constriction dividing it into a large basal part and a small apical part. A short spine-like structure



FIGS 24-28.- *Tasmanoonops magnus* sp. n. Male: 24-eyes; 25-prolateral side of left chelicera, 26-tarsal claws, 27-right palp. Female: 28-end of tarsus of palp.

projects from the apex and adjacent to it is a ligule covered with short hairs. On the retrolateral side of the apical division of the bulb a stout apophysis projects.

Abdomen ovoid, nearly twice as long as wide, covered with short hairs. Lung-slits and tracheal spiracles are in the usual position on the venter. Six spinnerets, the hind pair projecting beyond the others. Colulus with a number of setae is present.

projects from the apex and adjacent to it is a ligule covered with short hairs. On the retrolateral side of the apical division of the bulb a stout apophysis projects.

Abdomen ovoic, nearly twice as long as wide, covered with short hairs. Lung-slits and tracheal spiracles are in the usual position on the venter. Six spinnerets, the hind pair projecting beyond the others. Colulus with a number of setae is present.

Female

Measurements in mm:-

Body length	4.28
Carapace length	1.83
Carapace width	1.54
Abdomen length	2.40
Abdomen width	1.66

Leg	Femur	Patella	Tibia	Metatarsus	Tarsus	Total
1	2.00	0.80	1.71	1.66	0.63	6.80
2	1.94	0.86	1.71	1.66	0.68	6.85
3	1.60	0.57	1.14	1.26	0.57	5.14
4	2.29	0.63	1.60	2.00	0.68	7.20
Palp	0.63	0.29	0.34	-	0.74	2.00

Female resembles male in colour and appearance but has shorter legs. Palp has two trichobothria on tibia. Tarsus ends in a sharp point and has two large curved setae on the ventral side near apex (fig. 28). Anterior spinnerets lack hook-shape spines. Colulus resembles that of male.

Type locality: Western Creek, Tasmania, 1 ♂ (holotype), 1 ♀ (allotype), 2 ♂♂ (paratypes) from moss 21/1/1931; 3 ♀♀ (paratypes) from under decaying logs 29/1/1930 (V.V. Hickman).

Family ANAPIDAE Kratochvil, 1935

Spiders belonging to this family are less than 2.0 mm in body length. They have six or eight eyes in two rows. When present the anterior median eyes are diurnal. Clypeus is high. Chelicerae not fused together, without lateral condyles and without teeth on retromargin of furrow. Labium rebordered. Legs with metatarsi much shorter than tarsi. The three tarsal claws are non-pectinate. Accessory claws may be present or lacking. Female palp very small or reduced to a rudiment. Male palp long and with apophyses on one or more of the segments. Paracymbium lacking. Booklungs lacking, respiration by tracheal tubes.

Anapidae occur in moss and litter of rain-forests and sometimes under loose stones in damp situations. Some make orb webs like those of the Argiopidae, others construct irregular webs like those of the Theridiidae. Very little has been recorded concerning the Australian species.

Genus *ACROBLEPS* gen. n.

Diagnosis

Carapace high. Eight eyes in a close group. Cephalic region slightly constricted. Carapace high. Chelicerae with two teeth on promargin, none on retromargin. Male palp with tibial apophyses and a coiled embolus. Tarsi more than twice the length of metatarsi. Three tarsal claws. In both sexes abdomen soft without scutes or sclerites. A colulus and six spinnerets present. Book-lungs and posterior tracheal spiracle lacking. A pair of anterior tracheal spiracles lead into tracheae that are confined to the abdomen.

Type of genus: *Acrobleps hygrophilus* sp. n.

Acrobleps hygrophilus sp. n.

Male

Measurements in mm:-

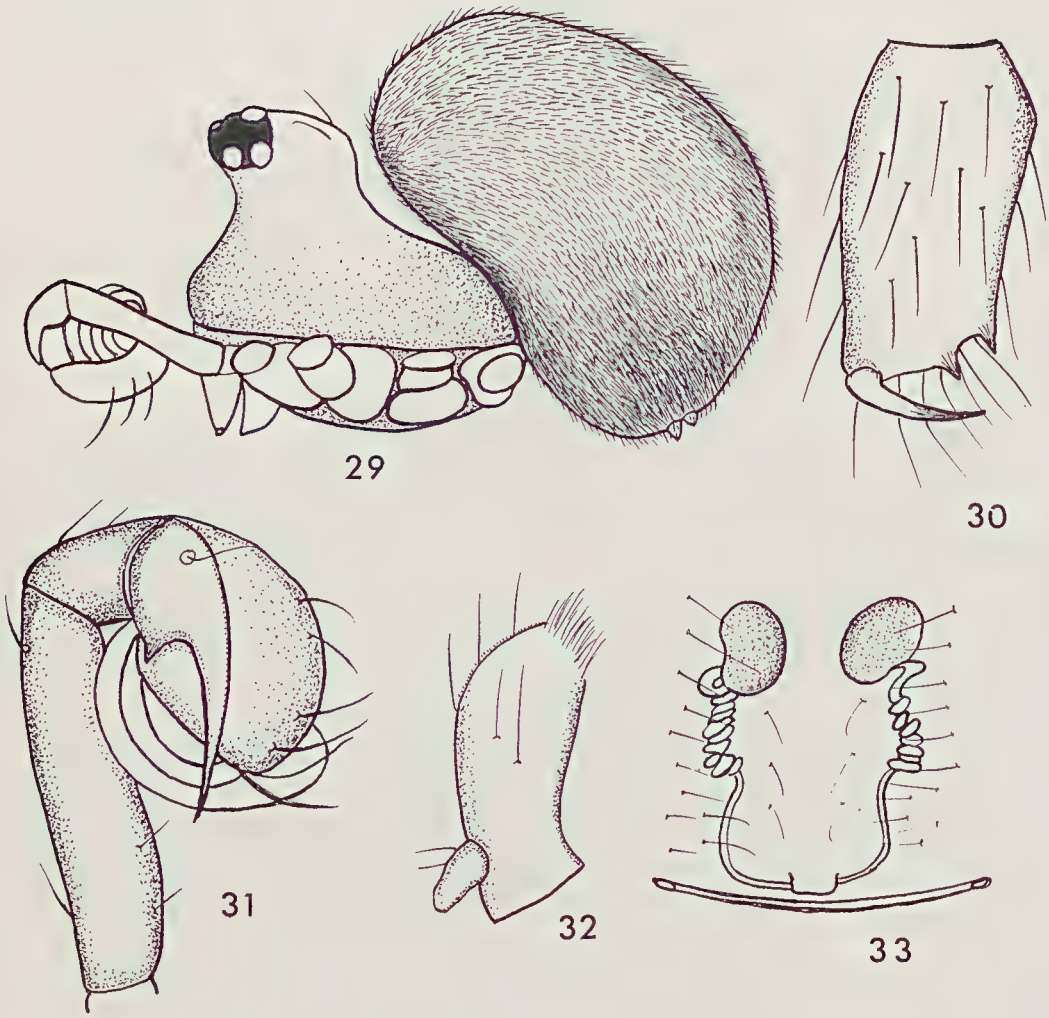
Body length	1.10
Carapace length	0.58
Carapace width	0.52
Abdomen length	0.81
Abdomen width	0.69

Leg	Femur	Patella	Tibia	Metatarsus	Tarsus	Total
1	0.62	0.22	0.44	0.21	0.51	2.00
2	0.56	0.21	0.40	0.19	0.49	1.85
3	0.45	0.19	0.31	0.18	0.42	1.55
4	0.55	0.19	0.38	0.19	0.44	1.75
Palp	0.27	0.11	0.05	-	0.16	0.59

Body and appendages greyish brown, ocular region black, sternum dark brown. Carapace slightly longer than wide, high, rounded at the sides, declivous in front and behind. Cephalic part high and slightly constricted below the eyes, projecting forward but not overhanging front margin (fig. 29). Thoracic grooves indistinct. Eight eyes in two rows forming a close group. Viewed from above the front row appears strongly recurved, hind row almost straight. Ratio of eyes AME:ALE:PME:PLE = 3:5:5:5; AME separated from each other and from ALE by 1/3 their diameter. Lateral eyes contiguous. PME separated from each other by 1/3 and from PLE by 2/3 diameter of AME. Median ocular area wider behind than in front in ratio 8:7, its length equal to its posterior width. Height of clypeus seven times diameter of AME. Chelicerae conical, vertical, without lateral condyles, clothed with a few long setae in front. Furrow slightly oblique, two large teeth on promargin, none on retromargin (fig. 30), a row of five long barbed hairs behind retromargin. Fang strong and well curved. Maxillae converging in front of labium, clothed with a few long hairs, a scopula at apex and a well developed serrula on front margin. Labium three times wider than long, truncate in front and provided with three long hairs. Sternum convex, shield-shape, truncate behind, widely separating fourth coxae, surface clothed with a few long hairs pointing forward.

Legs in order of length 1.2.4.3.; clothed with long hairs, spines lacking but there is a bristle at the apex of each patella, two dorsal bristles on each tibia; the first tibiae also have a prolateral bristle. Three trichobothria on the tibiae of the first three legs, and four on those of the fourth legs. One trichobothrium on the metatarsi of the first three legs, none on those of the fourth legs. A drum is present near the base of each tarsus. Three tarsal claws without teeth. Accessory claws present.

Palpi about half the length of the body. Cymbium small and spoon-shape. Genital bulb provided with a long embolus coiled in a close spiral of about four turns, the end of the embolus being freely exposed on the retrolateral side of coil (fig. 31). Apex of tibia produced into a long sharp apophysis, which rests against the side of the cymbium, extending slightly beyond the apex. At the base of the tibia on the ventral side is a small tooth-like apophysis. The patella is extended into an apical point, which rests on the dorsal side of the tibia. The palp is flexed so that the coiled embolus rests against the femur, the whole appendage being turned inwards with its prolateral side facing upwards.



FIGS 29-33.- *Acrobleps hygrophilus* sp. n. Male: 29-body, 30-prolateral side of right chelicera, 31-right palp. Female: 32-maxillary endite with vestigial palp, 33-epigynum in transparent preparation.

Abdomen broadly ovoid, overhanging carapace almost to the head region, thickly clothed with long hairs, soft without scutes or sclerites. Book-lungs, lung-covers, and posterior tracheal spiracle lacking. A pair of anterior tracheal spiracles are present, one at each end of the epigastric furrow. The tracheal system is confined to

the abdomen. Six spinnerets and a colulus are present. The colulus has two setae.

Female

Measurements in mm:-

Body length	1.45
Carapace length	0.64
Carapace width	0.55
Abdomen length	1.00
Abdomen width	0.93

Leg	Femur	Patella	Tibia	Metatarsus	Tarsus	Total
1	0.92	0.32	0.69	0.33	0.64	2.90
2	0.82	0.30	0.59	0.29	0.62	2.62
3	0.64	0.26	0.45	0.26	0.56	2.17
4	0.77	0.26	0.58	0.27	0.59	2.47

Female resembles the male in colour and general appearance except for the following features: Carapace not as high. Clypeus convex from above down with a distinct groove below the eyes. Palpi vestigial being reduced to a small conical projection on the anterolateral surface of the maxillary endite near the base (fig. 32). Abdomen more globose than in male. The epigynum has the form shown in fig. 33. In transparent preparations the spermathecae appear as a single pair of rounded sacs, each with a spirally coiled duct leading to the external aperture.

Type locality: Myrtle Gully, The Cascades, Tasmania, 1 ♂ (holotype), 1 ♀ (allotype), 10 ♂ ♂ (paratypes) collected under stones at side of creek 13/12/1945 (V.V. Hickman).

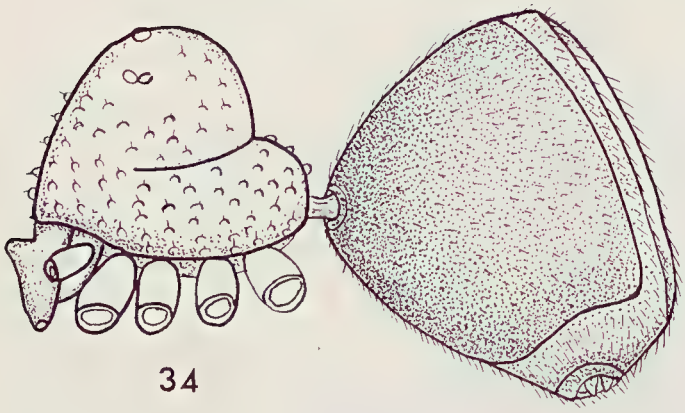
Habits: *Acrobleps hygrophilus* occurs in moist situations under loose stones on the margins of creeks in fern gullies. It is not unusual to find the spider on the undersurface of a stone below which water is actually flowing, provided the surface is not submerged. The spider spins an orb web, which is suspended horizontally across any convenient depression in the surface of the stone. A specimen of *Acrobleps hygrophilus* was kept alive in a small specimen tube, the inner surface of which had been moistened with a drop of water. Collembola were provided as food. Under these conditions the spider spun its web in the tube and the web was easily examined under the microscope. It was about 20 mm in diameter with 11 rays and 30 turns in the viscid spiral. It had a small irregular hub slightly drawn up by a thread from above. No notched zone was constructed. The distance between adjacent turns in the viscid spiral was 0.24 mm. In a length of 1.0 mm of the viscid thread there were 125 viscid droplets.

Affinities: In spinning an orb web and in the female having reduced palpi, *A. hygrophilus* resembles spiders in the genera *Risdonius*, *Chasmocephalon* and *Patu*. It differs from *Risdonius* in lacking book-lungs, lung-covers and a posterior tracheal spiracle; from *Chasmocephalon* and *Patu* in its tracheal tubes not entering the cephalothorax, and also from *Patu* in having eight eyes and non-fused chelicerae. Forster (1959) placed the three genera mentioned above in the family Symphytognathidae, but in a more recent revision of that family by Forster and Platnick (1977) *Risdonius* and *Chasmocephalon* are transferred to the family Anapidae.

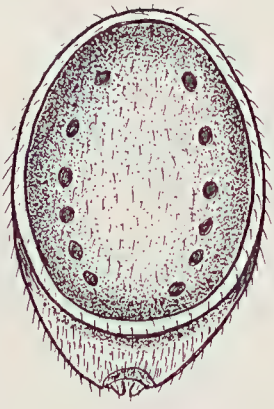
Genus *OLGANIA* gen. n.

Diagnosis

Carapace high, six eyes, cervical groove strongly marked. Patella and tibia of male palp with apophyses, genital bulb with a long embolus. Female palp without claw. Dorsal and epigastric scutes fused together in both sexes investing the greater part of abdomen. Posterior end of abdomen deeply indented in both sexes. Book-lungs and



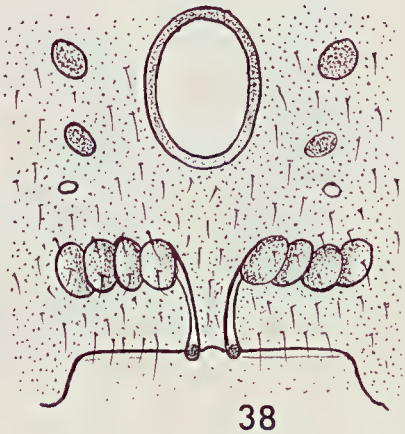
34



37

36

35



38

FIGS 34-38.- *Olgania excavata* sp. n. Male: 34-body, 35-retrolateral side of left chelicera, 36-left palp, 37-hind view of abdomen. Female: 38-epigynum in transparent preparation.

posterior tracheal spiracle absent. A pair of anterior tracheal spiracles open on epigastric scute. Some tracheae enter cephalothorax. Six spinnerets and a colulus surrounded by a sclerotized ring.

Type of genus: *Olgania excavata* sp. n.

Olgania excavata sp. n.

Male

Measurements in mm:-

Body length	0.91
Carapace length	0.43
Carapace width	0.39
Abdomen length	0.50
Abdomen width	0.46

Leg	Femur	Patella	Tibia	Metatarsus	Tarsus	Total
1	0.53	0.11	0.42	0.20	0.32	1.58
2	0.47	0.11	0.40	0.17	0.32	1.47
3	0.46	0.10	0.31	0.17	0.29	1.33
4	0.53	0.11	0.45	0.20	0.34	1.63
Palp	0.21	0.10	0.08	-	0.15	0.53

Cephalothorax and appendages brownish yellow. Sclerotized parts of abdomen light brown, soft parts greyish white.

Carapace (fig. 34) high, sloping steeply to hind margin. Cervical groove strongly marked. Clypeus higher than length of chelicerae and inclined slightly backward. Surface of carapace with numerous tubercles, each with a small seta. Six eyes, a median pair and two lateral pairs. Median pair separated from each other by half their diameter and from the laterals by four times that distance. Laterals contiguous. All the eyes about equal in size.

Chelicerae vertical, without lateral condyles. In front near the base a low apophysis directed mesad. Fang well curved. Dentition difficult to see but appears to be like that of female (fig. 35). Maxillae strongly converging over front of labium and provided with a small scopula at the apex and a serrula on front margin. Labium longer than wide, pointed in front and partly concealed by the converging maxillae. Sternum slightly wider in front than long, rounded at the sides, truncate behind widely separating the fourth coxae. Margin rebordered and extended upward forming a series of condyloid cavities into which the bases of the coxae fit. Surface of sternum convex, clothed with a few short setae interspersed with low tubercles.

Legs in order of length 4.1.2.3. A bristle at the apex of each patella and two on each tibia. Two trichobothria on first tibiae, three on second and third, four on the fourth. One trichobothrium on each metatarsus except the fourth, which has none. A drum near the base of each tarsus. Three tarsal claws; no accessory claws.

Palpi have two large apophyses on patella, the more basal one curved downward with a seta at its free end, the distal one larger, curved upward, with a forked apex. The tibia has a small setigerous tubercle on the retrolateral side and two larger tubercles on the prolateral side, each with a long seta extending over the genital bulb. Cymbium small with a fringe of long hairs at the apex. Embolus long, slender, arising near base of bulb it passes round the bulb and the apex of the cymbium to end slightly beyond the forked apophysis on the patella (fig. 36).

The abdomen has a strongly sclerotized investment surrounding the anterior two thirds (fig. 34). This appears to be formed by the fusion of a large dorsal scute with the epigastric scute. The posterior third of the abdomen is deeply indented forming a cavity, which has a row of six small sclerites on each side (fig. 37). The surface of the abdomen is clothed with short hairs, those on the dorsum and sides each arising from sclerotized base. The six spinnerets and colulus are surrounded by a

large sclerotized ring. Book-lungs and posterior tracheal spiracle are lacking. A pair of anterior tracheal spiracles open on the epigastric scute. Some tracheae enter the cephalothorax.

Female

Measurements in mm:-

Body length	0.92
Carapace length	0.42
Carapace width	0.36
Abdomen length	0.50
Abdomen width	0.49

Leg	Femur	Patella	Tibia	Metatarsus	Tarsus	Total
1	0.49	0.10	0.39	0.17	0.35	1.50
2	0.39	0.10	0.35	0.15	0.32	1.31
3	0.35	0.08	0.25	0.14	0.29	1.11
4	0.42	0.11	0.40	0.17	0.33	1.43
Palp	0.12	0.04	0.07	-	0.08	0.31

Female resembles the male in colour and form with a similar sclerotization and deep indentation of the abdomen. Carapace, however, is not so high. Tarsi with a drum and lacking a claw.

Epigynum (fig. 38) has the form of two short median grooves leading to a pair of small rounded projections at middle of epigastric furrow. Below the projections are the apertures of the ducts leading to the spermathecae. The latter appear through the integument as a pair of large convoluted tubes or sacs extending laterally beyond the ends of the epigastric furrow.

Type locality: Southwestern Tasmania, Gordon River Valley, 145° 44.5' E, 42° 35.5' S, 1 ♂ (holotype) from moss 4/2/1976 (C. Howard *et al.*); 145° 49'E, 42° 43.2' S, 1 ♀ (allotype) from moss about 1.5 km west of junction of Gordon and Denison Rivers, 16/2/1978 (L. Hill *et al.*); 145° 50' E, 42° 43' S, 1 ♀ (paratype) from moss in the same area (L. Hill *et al.*).

Family MYSMENIDAE

Petrunkevitch (1928) established the Mysmeninae as a sub-family of the Theridiidae. Gertsch (1960) transferred it to the Symphytognathidae. Forster and Platnick (1977) raised it to rank as a family, the Mysmenidae. The chief characters of the family are as follows:-

Small spiders, mostly 1.0 - 3.0 mm in length. Carapace high. Abdomen soft without scutes. Eyes eight. Tarsi longer than or equal to the metatarsi. Three tarsal claws without teeth. No comb on fourth tarsi. Female palp not vestigial but lacking a claw. Male usually with a clasping spine on first metatarsi. A colulus and six spinnerets present. Apneumone or with book-lungs.

Little is known concerning the habits of these minute spiders. Some are recorded as spinning irregular webs (Gertsch 1960).

Genus *MYSMENA* Simon, 1894

Mysmena tasmaniae sp. n.

Male

Measurements in mm:-

Body length	0.75
Carapace length	0.41

Carapace width	0.33
Abdomen length	0.57
Abdomen width	0.45

Leg	Femur	Patella	Tibia	Metatarsus	Tarsus	Total
1	0.31	0.12	0.26	0.16	0.20	1.05
2	0.26	0.11	0.22	0.15	0.19	0.93
3	0.20	0.10	0.14	0.14	0.18	0.76
4	0.27	0.11	0.19	0.15	0.19	0.91
Palp	0.20	0.07	0.07	-	0.14	0.48

Carapace dark brown on head region, paler posteriorly and at the sides. Sternum with dark marks on each side. Legs yellow with dark rings. Abdomen almost black with four large white spots on dorsum, and two smaller ones on each side. A white area above the spinnerets extends partly onto the sides and ventral surface (fig. 39). Head region high and slightly overhanging clypeus. Eight eyes in two transverse rows; hind row almost straight, front row procurved. Eye ratio AME:ALE:PME:PLE = 13:12:15:12. AME separated from each other by 17/13 of their diameter and almost touching ALE. PME separated from each other by 1/13 of their diameter and from PLE by the same distance. Height of clypeus 7/3 diameter of AME.

Chelicerae (figs 40 and 41) 0.18 mm long and 0.07 mm wide, conical, vertical, without lateral condyles; a small apophysis and stridulating ridges on mesal side. Furrow oblique with three large teeth on promargin and a group of small teeth behind them in the furrow. Maxillae strongly converging over labium, with a small scopula at apex and a serrula on front margin. Labium triangular and as long as wide. Sternum shield-shape, slightly longer than its anterior width, truncate behind separating the fourth coxae by almost twice their diameter.

Legs in order of length 1.2.4.3., the second and fourth pairs almost equal. A stout, curved prolateral spine on the distal third of the first metatarsus (fig. 42). Two trichobothria on first and second tibiae, three on third and fourth, but some variation occurs in different specimens. One trichobothrium on each metatarsus except the fourth, which has none. A small sclerotized spot on the ventral side of the first and second femora about 1/3 from distal end (fig. 43). Tarsus has a drum almost at the junction with metatarsus, three pectinate claws but no accessory claws.

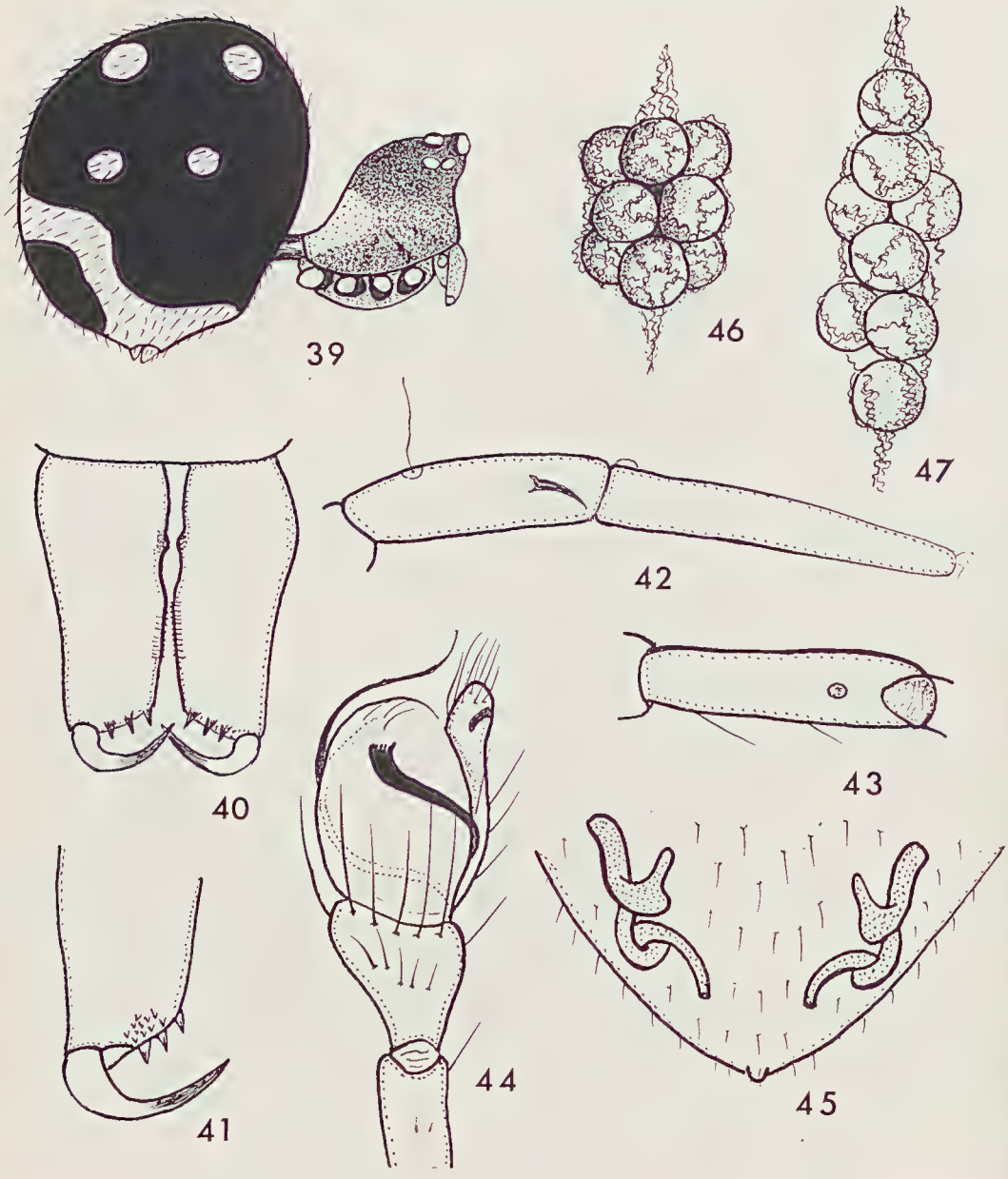
Palpi have a relatively long femur equal to that of the third pair of legs. No apophyses occur on any of the segments. The cymbium has a short hook-like spine near the apex. Embolus long and slender; it arises from the surface of the genital bulb and makes a complete turn round the bulb ending near the apex of the cymbium (fig. 44).

Abdomen rounded without a caudal hump, clothed with short simple setae. Book-lungs, lung covers and posterior tracheal spiracle lacking. A pair of anterior tracheal spiracles are situated one at each end of the epigastric furrow. A number of tracheal tubes enter the cephalothorax. Six spinnerets and a colulus are present.

Female

Measurements in mm:-

Body length	0.97
Carapace length	0.39
Carapace width	0.35
Abdomen length	0.61
Abdomen width	0.58



FIGS 39-47.- *Mysmena tasmaniae* sp. n. Male: 39-body, 40-prolateral view of chelicerae, 41-retrolateral side of left chelicerae, 42-metatarsus and tarsus of first leg, 43-ventral side of first femur showing sclerotized spot, 44-right palp. Female: 45-epigynum in transparent preparation, 46-egg-mass as laid, 47-egg-mass extended.

Leg	Femur	Patella	Tibia	Metatarsus	Tarsus	Total
1	0.33	0.14	0.23	0.18	0.19	1.07
2	0.27	0.11	0.20	0.15	0.19	0.92
3	0.20	0.11	0.16	0.12	0.16	0.75
4	0.30	0.12	0.20	0.16	0.19	0.97
Palp	0.12	0.05	0.07	-	0.12	0.36

Female is slightly larger than the male, but has the same colouration, markings and general features. However, the carapace is not as high, chelicerae shorter, without stridulating ridges or apophysis on mesal side. Female has no claw on palp and also lacks a clasping spine on the first metatarsus. Epigynum a triangular lobe ending in a small knob-like scape (fig. 45). Spermathecae have the form of a pair of twisted tubes, when seen in transparent preparations.

Type locality: Maxwell River Valley, Southwestern Tasmania, 145° 55' E, 42° 38' S, 1 ♂ (holotype); 145° 54' E, 42° 38' S, 1 ♀ (allotype) from leaf litter 5/1/1978 (L. Hill *et al.*).

Other localities: Tarraleah, Tasmania, 1 ♂ from moss 11/5/1953 (V.V. Hickman); East Risdon, Tasmania, 1 ♀ from grass tussocks 23/9/1975 (V.V. Hickman); various valleys in southwestern Tasmania, 12 ♂♂, 25 ♀♀ from moss and forest litter, January, February and March, 1976, 1977 and 1978 (C. Howard, L. Hill *et al.*).

Affinities: *Mysmena tasmaniae* has a strong resemblance to the American species *Mysmena incredula* (Gertsch and Davis). It differs in the form of the spermathecae, in having a hooked spine on the cymbium of the male and to a lesser degree in abdominal markings.

Habits and life cycle: Under laboratory conditions *Mysmena tasmaniae* spun a small web amongst some grass-stalks. The web was formed of a few irregular threads, most of which were in a horizontal plane. The spider rested below the web the threads of which were not viscid and did not ensnare prey. Small Collembola were provided as food. If one of these disturbed a thread of the web, the spider rushed to the spot and caught the insect. The prey was not wrapped up in threads, but killed and suspended in the web until required.

Breeding occurs during spring and summer. In mating the male approaches the female and takes up a position immediately in front of her, extending his left palp across her sternum. The long femur of the palp enables the epigynum to be reached from in front of the female. The act of copulation was observed under the microscope. The male first employed his left palp, inserting the embolus in the right spermathecal aperture of the female. It was soon withdrawn and again inserted. This occurred about eight times in five minutes. The male then applied his right palp to the left spermathecal aperture of the female in a similar manner. After copulation the male retired to the outer parts of the web and moved about actively, occasionally stopping to pluck the threads and to draw his first and second tarsi between his chelicerae. Meanwhile the female remained below the web and also often plucked the threads. If the male approached a second time, the female plucked the threads more rapidly and he retired. Eggs were laid three days after mating.

The eggs, eight to twelve in number, measure 0.35 mm in diameter and are yellowish in colour. They are not enclosed in an egg-sac or capsule (fig. 46), but are held together in a mass by a few crinkled threads. Under laboratory conditions one female laid six lots of eggs during the period 25 October 1975 to 9 January 1976. The egg mass is suspended below the web, and when the eggs are first laid, the mass measures 1.15 mm long and 0.74 mm in greatest width. However, the spider, which rests

below the eggs, sometimes pulls on the enveloping threads, loosening the eggs and thus causing the mass to elongate to 2.4 mm (fig. 47).

Incubation lasts 10-15 days and after hatching the spider passes through two to four instars before reaching maturity. The first postembryonic instar appears to occur within the egg and its duration is not shown separately in Table 1, but is included in the duration of incubation. On hatching the instar that escapes from the ruptured chorion has the features of a normal second postembryonic stage - thus it is clothed with setae, has three tarsal claws, moves actively and is able to spin. As is shown in Table 1 there is considerable variation in the duration of the juvenile instars. The total time from egg-laying to maturity is 29 - 52 days. This very short life cycle makes it possible for at least three generations to be passed through in the one summer.

TABLE 1

Mysmena tasmaniae sp. n. Duration (in days) of incubation and juvenile instars of ten specimens (A-J) bred in the laboratory

	Egg laid	Incubation	Instar II	Instar III	Instar IV	Instar V	Total	Sex
	1975							
A	25 Oct.	15	16	11	6	-	48	♀
B	25 Oct.	15	17	12	8	-	52	o
C	25 Oct.	15	21	8	7	-	51	o
D	15 Nov.	12	4	11	6	8	41	♀
E	29 Nov.	9	18	9	8	-	44	o
F	29 Nov.	9	22	9	-	-	40	♀
G	28 Dec.	10	10	5	8	-	33	♀
H	28 Dec.	10	10	3	6	-	29	o
I	28 Dec.	10	10	10	14	-	44	♀
J	28 Dec.	10	20	2	14	-	46	♀

The type specimens of new species described in this paper will be lodged in the Australian Museum, Sydney, and paratypes, where available, in the Tasmanian Museum and Art Gallery, Hobart. The allotype of *Oonopinus mollipes* will be lodged in the Queen Victoria Museum, Launceston, where the holotype was deposited in 1932.

REFERENCES

Forster, R.R., 1959: The spiders of the family Symphytognathidae. *Trans. R. Soc. N.Z.*, 86: 269-329, figs 1-158.

_____ and Platnick, N.I., 1977: A review of the spider family Symphytognathidae. *Amer. Mus. Novitates*, 2619, 1-29, figs 1-74.

Gertsch, W.J., 1960: Descriptions of American spiders of the family Symphytognathidae. *Amer. Mus. Novitates*, 1981, 1-40, figs 1-72.

Hickman, V.V., 1930: Studies in Tasmanian spiders, Part IV. *Pap. Proc. R. Soc. Tasm.* (1929): 87-122, pl. 19-26.

_____, 1932: Studies in Tasmanian spiders, Part V (The Oonopidae). *Pap. Proc. R. Soc. Tasm.* (1931): 2031, figs 1-11.

Kratochvil, J., 1935: Araignees cavernicoles de Krivosije. *Prace. Morav. prirod. spol.*, 9(12): 1-25, figs 1-21.

Petrunkevitch, A., 1928: Systema Aranearum. *Trans. Connecticut Acad. Arts. Sci.*, 29: 1-270.

Simon, E., 1893: Arachnides in Voyage de M.E. Simon au Venezuela (Decembre 1887 - Avril 1888) 21^{e}. *Memoire. Ann. Soc. Ent. Fr.*, 61: 423-462, pl. 9.

_____, 1894: Histoire naturelle des araignées, I (3): Paris, 1894, 489-760, figs 491-837.

Templeton, R., 1835: On the spiders of the genus *Dysdera* Latr. with the description of a new allied genus. *Zool. J.*, 5: 100-108, pl. 17.

Papers and Proceedings of the Royal Society of Tasmania, Volume 113, 1979

(ms. received 21.4.1978)

TOWARDS A HUMAN PREHISTORY IN THE LOWER DERWENT RIVER AREA, SOUTH-EASTERN TASMANIA, AUSTRALIA

by Jim Stockton[1] and Alan Wallace[2]
[1]National Parks and Wildlife Service and [2]University of Tasmania

(with one table and one text-figure)

ABSTRACT

STOCKTON, J. and WALLACE, A., 1979 (20 vii): Towards a human prehistory in the lower Derwent River area, south-eastern Tasmania, Australia. *Pap. Proc. R. Soc. Tasm.*, 113: 81-84. ISSN 0080-4703. National Parks and Wildlife Service, Magnet Court, Sandy Bay Tasmania and Department of Anatomy, University of Tasmania, Hobart, Tasmania, Australia.

A review of the published and unpublished reports on the archaeology of the lower Derwent River area, south-eastern Tasmania, Australia is presented.

THE PROBLEM

The current gap in the archaeological sequence of the Derwent is the recent period. There is a dearth of ethnohistorical data for the area during the early years of settlement. Work done in the area to date has been haphazard, and has lacked an overall research goal perspective. Most excavators have been pre-occupied with the maximum antiquity rather than the delineation of a regional archaeological sequence.

OLD BEACH

An Old Beach site was excavated by Sigleo (1975) (fig. 1).

Old Beach is located approximately 18 km north of Hobart on the eastern margin of the Derwent estuary. Geomorphological investigations of source bordering sand sheets in the lower Derwent Valley during 1971-73 revealed the presence of several artifacts in a trench at Old Beach. The site which borders the confluence of the River Jordan at Herdsmans Cove with the estuary of the Derwent was excavated by Sigleo and Colhoun, 1975 (fig. 1). The stratigraphic position of the artifacts suggested that this site could provide evidence for the oldest human occupation in south-eastern Tasmania. The artifacts in Sigleo's Unit 3 suggest a Late Pleistocene age for Man in Tasmania. This period of occupation predates 9 000 - 11 000 BP by an unknown amount. In Sigleo's Unit 2 two hearths were sectioned and charcoal and shells of the common edible mussel *Mytilus planulatus* were dated by C14. The dates obtained were 5800 ± 130 (SUA - 306) and 5600 ± 130 BP (SUA - 306) and 5600 ± 100 BP (SUA - 307). The dated hearths associated with Sigleo's Unit 2 and the truncated surface of Unit 3 suggest that a relatively continuous phase of Aboriginal occupation had commenced in this area by at least 5800 radiocarbon years ago.

Reber (1965, p.266) dated a site on a small peninsula on the east side of the Derwent River opposite Dogshear Point. The midden was about 9m A.S.L. and covered an area of several hundred m^2. The sample was taken from 1.37m below the surface and dated 5200 ± 110 years BP (1 - 324).

SHAG BAY

Shag Bay, is a few hundred metres north of Geilston Bay (Tasmanian Aboriginal Sites Index Card No. 18) (fig. 1) and directly opposite New Town near the city of

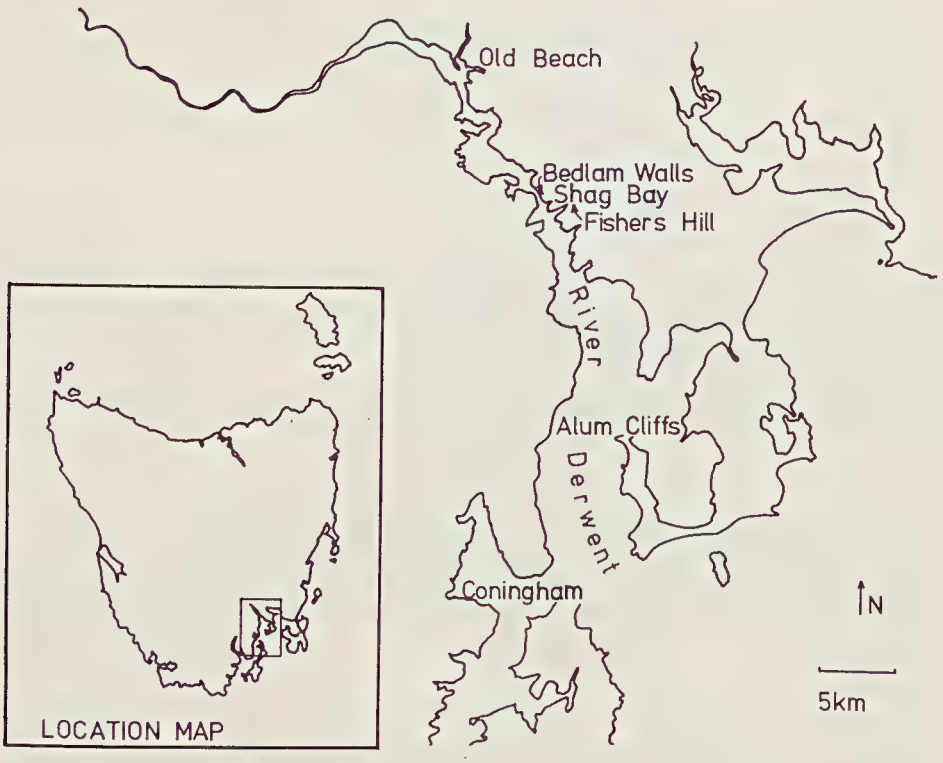


FIG. 1.- Map showing excavated sites in the Derwent estuary.

Hobart. It is 24 km from the mouth of the estuary. Mussels, *Mytilus planulatus*, and the common mud oyster, *Ostrea angasi*, are the largest of the shellfish known to have lived in this part of the Derwent estuary, though several small species have been observed.

Nearly 2 km of steep, horizontally-bedded 30 metre high mudstone cliffs mark the eastern shore of the estuary immediately north of Geilston Bay. Midway along this cliff (The Bedlam Walls) 100 metres to the south of Shag Bay, is a series of rock-shelters, many of which show evidence of Aboriginal occupation in the form of mussel shells eroding out of the floor deposits. The rock shelter chosen by Vanderwal (1977) for excavation is 15m above the level of the river. It is the largest and most accessible of those in the cliff being 12m long and 4m deep. It has a westerly aspect across the Derwent River. Carbon samples were collected from near the top of the occupation zone (SB 2/7, GaK 5424 : 4720 ± 110 years BP) and another from the base (SB 2/15, GaK 5425 : 5300 ± 120 years BP). The date difference of 700 years suggests that the rockshelter was used for probably less than 1 000 years. Shag Bay rockshelter was seen by Vanderwal as an extreme example of the east coast pattern of intensive single resource utilisation and nomadism.

Jim Stockton and Alan Wallace

FISHERS HILL

An open midden on Fishers Hill was excavated by Wallace in 1973 (fig. 1). The area is immediately south and east of Shag Bay and is part of the area often also referred to as Bedlam Walls. The site excavated was on the shoulder of a hill near the 50m contour facing north-west across Shag Bay. No clear margin of the deposit existed but the midden was oval in shape and covered about 60m^2. The first part of the excavation near the centre of the deposit showed 0.54m of midden deposit resting on the mudstone bedrock. Four ill-defined layers were recorded. No artifacts were recovered in this pit.

A feature of this excavation was the absence of any transitional zone of shell-free earth above the bedrock. A second pit 3m x 1m was therefore excavated which proved 0.1m of topsoil on 0.38m of shell midden which in turn lay on the mudstone bedrock. The shell deposit was lenticular in section, and beyond it the topsoil graded through to bedrock. Several stone artifacts were found. This site is interpreted as a meal site of temporary nature which was repeatedly visited. The bottom of the deposit was dated by C14 as follows: Shell carbonate 5420 ± 85 BP (ANU 1090 A), acid insoluble organic fraction 5890 ± 90 (ANU 1090 B) years BP. These dates show that this site is close in time to the Shag Bay site, the Old Beach site and Reber's site 12 near Old Beach.

ALUM CLIFFS

An open midden site at Alum Cliffs, Kingston, was excavated by Stockton in 1975 (Tasmanian Aboriginal Sites Index Card No. 20) (fig. 1). The site was c. 600m^2 in area and 0.5m deep. It was hoped that this site would be of similar antiquity to sites excavated higher up the Derwent but that it would represent a fully marine resource zone. Marine shells were recovered throughout the deposit. Stone artifacts, a piece of ochre, and a scallop shell with a hole in the centre were recovered. The bottom of the deposit rested on the siltstone bedrock, and charcoal from it dated 3875 ± 160 BP (SUA - 599).

CONINGHAM

The Coningham site was excavated by Stockton and Wallace in 1976 (Wallace and Stockton, 1979) as a rescue excavation of eroding skeletal material (Tasmanian Aboriginal Sites Index Card No. 126). It is located on the bank above a beach on the side of the D'Entrecasteaux Channel. The sandy beach is approximately 300m long and has cliffs at either end. A gully meets the beach about 15m from the area excavated. The vegetation adjacent to the site is open dry eucalypt forest, probably altered by European land use. This occurrence is significant because so little of the Tasmanian skeletal material has been excavated with archaeological control from an undamaged site.

There is no sign of bone-burning, a hearth or a pit for burial. Some of the large mud oyster shells near the body were standing on edge rather than lying flat as is usual. They appeared to form an incomplete circle. The body was then disturbed by the carnivores which led to the breaking of long bones and displacement of the bone fragments. The bones were then gradually covered by sand blown from the beach, a process still continuing. A charcoal sample associated with the skeletal material dated 840 ± 95 BP (SUA - 626), the youngest date so far obtained for the Derwent estuary.

BEDLAM WALLS SURVEY

Jacklyn (1975) has made an intensive survey of the Bedlam Walls area (fig. 1)

and collected more than 600 artifacts. This shows the high density of occupation sites for this area.

TABLE 1

DATA FROM BEDLAM WALLS SURVEY

Type of Site		Number	
mound entire or almost entire		30	
mound largely destroyed		21	
mound not clearly defined		3	
large concentration of shell and ash		18	
traces of shell and ash		5	
rock shelter		3	
	Occupation sites	80	
quarry - opal - quartz		2	
- mudstone		1	
		3	Total 83

COMMENT

This paper has collated archaeological work in the lower Derwent area using much previously unpublished material. There is a need for new sites covering the past four millenia to fill in the prehistory of Aboriginal occupation.

REFERENCES

Jacklyn, R.M., 1975: Bedlam Walls Occupation Sites. Unpublished Report.

Reber, G., 1965: Aboriginal Carbon Dates from Tasmania. *Mankind*, 6(6): 264-268.

Sigleo, W.R. and Colhoun, E.A., 1975: Glacial Age for Man in Southeastern Tasmania : Evidence from the Old Beach Site. *Search*, 6(7): 300-302.

Tasmanian Aboriginal Sites Index. National Parks and Wildlife Service, Hobart.

Vanderwal, R.L., 1977: The Shag Bay Rock Shelter, Tasmania. *The Artefact*, 2(4): 161-70.

Wallace, A.G. and Stockton, J., 1979: Skeletal Remains at Coningham, Tasmania, Australia. *Pap. Proc. R. Soc. Tasm.*, 113: 149-153.

Papers and Proceedings of the Royal Society of Tasmania, Volume 113, 1979

(ms. received 24.2.1978)

TWO NEW TERRESTRIAL SPECIES OF *TALITRUS* (AMPHIPODA: TALITRIDAE) FROM TASMANIA

by J.A. Friend
Department of Zoology, University of Tasmania

(with one table and five text figures)

ABSTRACT

FRIEND, J.A., 1979 (20 vii): Two new terrestrial species of *Talitrus* (Amphipoda: Talitridae) from Tasmania. *Pap. Proc. R. Soc. Tasm.*, 113: 85-98. ISSN 0080-4703. Department of Zoology, University of Tasmania, Hobart, Tasmania, Australia.

Two new species of terrestrial amphipod from the soil and litter of Tasmanian forests are described and figured. They are provisionally placed in the genus *Talitrus* Latreille (*sensu* Hurley 1955) and, with *T. kershawi* Sayce, in the subgenus *Keratroides* Hurley (1975), which is seen as a highly specialised group of land-hoppers.

INTRODUCTION

Terrestrial amphipods (family Talitridae) were first recorded from Tasmania by Haswell (1881), who described *Talitrus assimilis* from the island, pointing out slight differences which set it apart from *T. sylvaticus* Haswell. In 1885 he synonymised these two species (calling the former species *T. affinis* by mistake). Thomson (1892) described and figured some terrestrial amphipods from Mt. Wellington, near Hobart, assigning them to *T. sylvaticus*. Later Sayce (1909), in his redescription of *T. sylvaticus* from Victoria, mentioned that this species was "very common in Tasmania", but named no material. In 1925, Hunt included some drawings of an unnamed Tasmanian species in his paper on the genus *Talitrus*, but later Ruffo (1949) named this species *T. tasmaniae* Ruffo on the basis of two specimens lodged in an Italian museum, and identified a third specimen as *T. sylvaticus*. Hurley's paper on the genus *Talitrus* in New Zealand (1955) included some figures of Tasmanian material which he identified as *T. kershawi*.

Thus no major work has yet appeared on the taxonomy of Tasmanian terrestrial amphipods. Recent unpublished work has shown that the island has a relatively diverse terrestrial talitrid fauna, and descriptions of two species are presented here. Both are placed in the genus *Talitrus* Latreille, as redefined by Hurley (1955), for reasons discussed below.

TAXONOMY

Family TALITRIDAE Stebbing emend. Bulycheva 1957

Talitrus vulgaris n.sp.
(figs 1-3)

Talitrus sylvaticus Thomson Pap. Proc. R. Soc. Tasm. (1892) *(partim)* - *Talitrus sylvaticus* Ruffo Ann. Mus. civ. Stor. Nat. Genova 63, (1949) - *Talitrus kershawi* Hurley Pac. Sci. 9, (1955).

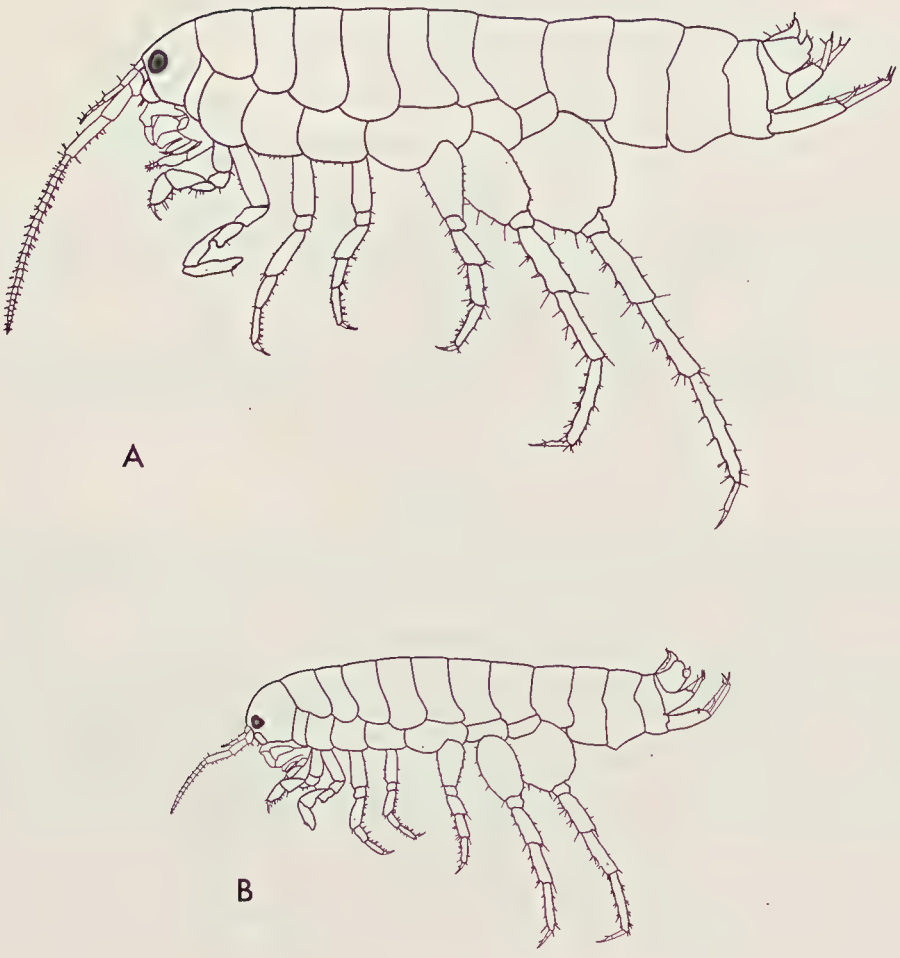


FIG. 1.- a. *Talitrus vulgaris* n.sp., holotype ♀, 11.5 mm; x 7.5. b. *Talitrus angulosus* n.sp., holotype ♀, 7.1 mm; x 7.5.

Description

Female

11.5 mm long; variation in other specimens shown in square brackets. Head as long as deep, dorsal surface gently curving. Eye round, about one third as wide as head is long. Antenna 1 short, almost reaching middle of distal peduncular segment of antenna 2. Flagellum of five segments [range 3-5], shorter than peduncle. Antenna 2, flagellum of 24 segments [range 8-28] each bearing four groups of three spines, except

the distal segment, which bears a group of six or more, and the proximal segment, single spines; peduncle shorter, distal segment as long as penultimate two combined. Upper lip shallow, broad, apically pilose. Lower lip broad, inner shoulders pilose, sides of central trough lightly pilose. Mandible, incisor 3-toothed, left lacinia bicuspate, large cusp with four teeth, molar process well developed. Maxilla 1, inner plate short, narrowing distally, inner margin setose, outer plate setulose proximally, palp situated distal of midpoint of outer margin, very small, 2-jointed. Maxilla 2, outer plate the longer, outer margin bearing five small teeth distally. Maxilliped, inner plate with setose spines distally, three terminal teeth, inner small, others larger; outer plate short, narrowing distally, apex truncate and bearing spine groups at the corners (two spines on outer, nine on inner corner). Palp slender, bearing a few long spines, fourth segment delimited proximally by a slight shoulder.

Gnathopod 1, coxal plate broad with obtusely rounded distal margin, supplied with small spines. Segment 2 broadening slightly distally, poorly spined. Segment 3 shorter than 4, which bears a shallow posterior lobe. Segments 5 and 6, short, equal in length, segment 5 expanded deeply into a scabrous posterior lobe. Segment 6 gently narrowing distally, with strongly spined posterior margin forming a simple hand with the strong dactyl. Gnathopod 2, coxal plate subsquare, gently rounded below, posterior process very small, obtusely rounded. Gill large, with anterior and wide posterior extensions. Oöstegite entirely absent. Segment 2 linear, several large anterior spines. Segment 4 subequal to segment 3, with large scabrous tumid posterior lobe. Segment 6 equal in length to segment 5, both with scabrous posterior surfaces. Dactyl strongly exceeded by sharp apical lobe.

Peraeopods long, slender, larger spines bifid, especially on distal segments. Peraeopods 3 and 4, coxal plate deep, subquadrate, posterior process small, sharply rounded. Gill small, wider posteriorly. Oöstegite narrow, linear, with six long apical setae. Peraeopod 5, anterior coxal lobe shallow, lower margin oblique, lightly spinulose. Posterior lobe smaller, shallow, sharply rounding to slightly excavate posterior margin. Gill small, convoluted, reduced oöstegite of gill-like texture, held laterally across ventral surface. Segment 2, proximally broad, narrowing distally, hind margin straight, spinulose. Dactyl slender, terminal spine curved. Peraeopod 6, posterior coxal lobe moderately deep, squarish distally, hind margin smoothly rounded, weakly serrate. Anterior coxal lobe rounded distally, front margin gently excavate. Gill long, sinuous, proximally convoluted, then flattened, narrowing distally. Segment 2 subovate, posterior margin spinulose, distal lobe very small. Segments 4-6 slender, spinose. Dactyl slender, terminal spine long. Peraeopod 7, coxal plate subrectangular, posterodistally rounded and minutely serrate, with proximal anterior process. Segment 2 subcircular, posterior margin weakly serrate, distal lobe shallow. Segments 4-6 slender and spinose, dactyl slender, terminal spine long.

Epimeral plate 1 shallow, distal margin very slightly oblique. Posterior margin gently convex, weakly serrate and spinulose. Epimeral plate 2 subsquare, lower margin very gently rounded. Anterior corner round, anterior margin bearing one small spine. Posterior margin gently sinuous, weakly serrate and spinulose. Epimeral plate 3 exceeding second plate, lower margin gently convex, oblique anterior corner smoothly rounded; posterior margin gently sinuous, weakly serrate and spinulose along its length, posterior corner sharp.

Pleopods vestigial; peduncle of first short and slender, outer margin gently concave, inner bearing two coupling spines; a single terminal one-segmented ramus [sometimes two rami]: pleopod 2 similar, but both peduncle and ramus shorter; pleopod 3 reduced to a minute stump, with [or without] a small spine. [First instar specimens; pleopods reduced; peduncle of first short, slender, outer margin gently concave, bearing two coupling spines and sometimes a short simple spine; two unequal one-segmented rami present, the outer the longer, each with two long (and sometimes a

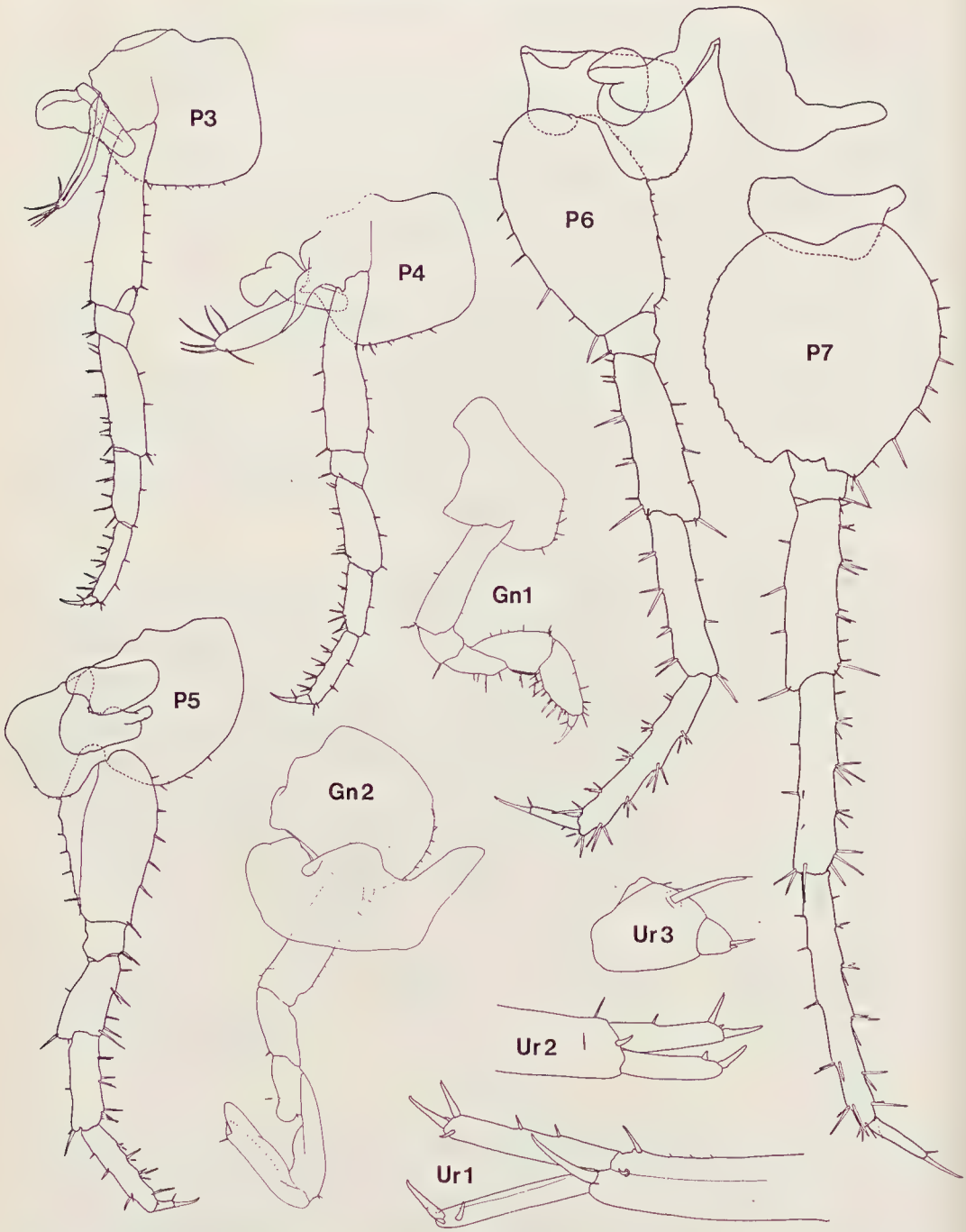


FIG. 2.- *Talitrus vulgaris* n.sp., holotype ♀, 11.5 mm. Gn 1 and 2, P 3-7-x20: Ur 1 and 2-x30: Ur 3-x60.

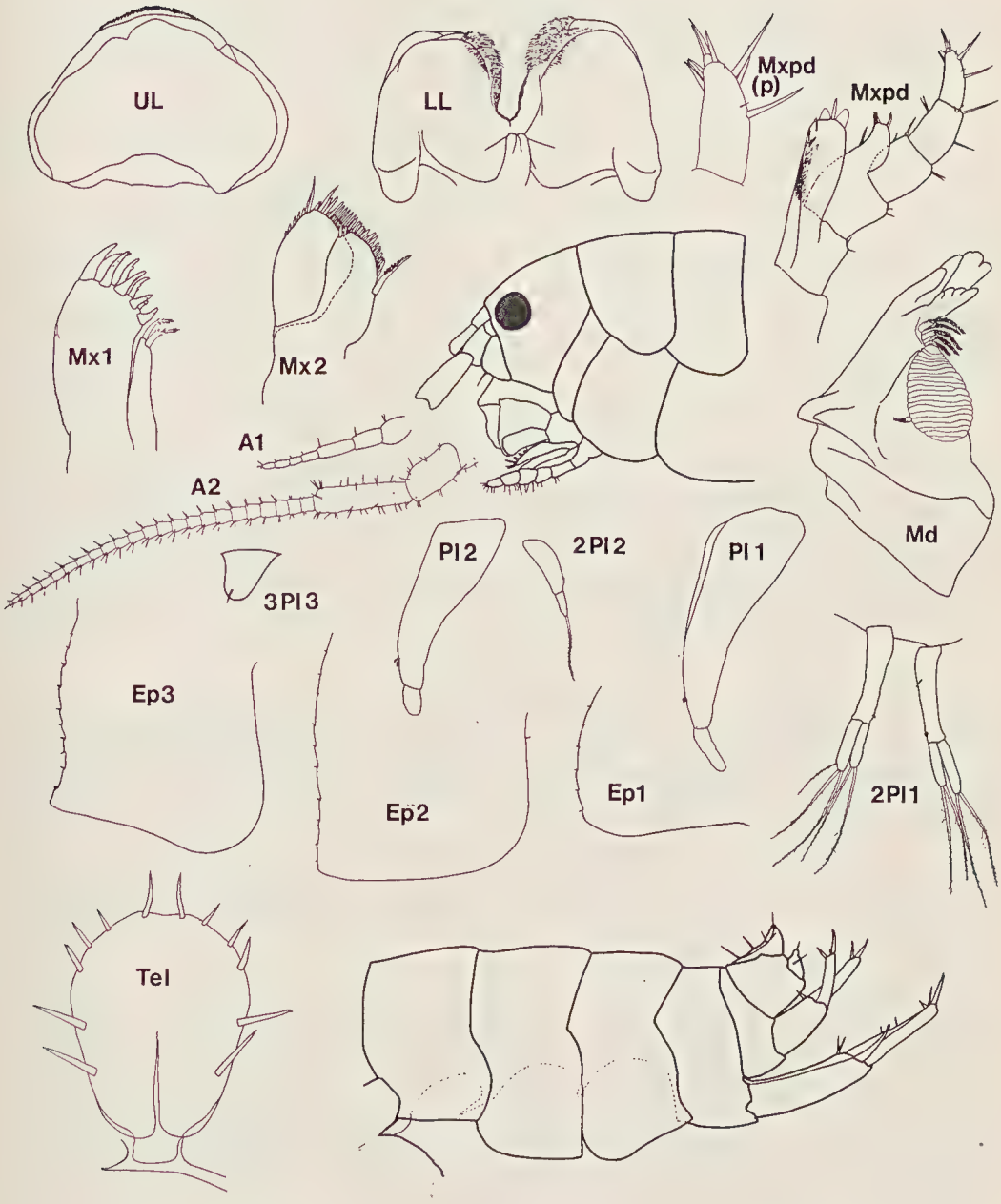


FIG. 3.- *Talitrus vulgaris* n.sp. holotype ♀, 11.5 mm; the prefix 2 applies to an instar 1 juvenile 4.0 mm, Tower Rd., Hobart; the prefix 3 applies to a male 10.4 mm, type locality: Mxpd(p): distal portion, right palp of maxilliped, dorsal view; Mx1, Mx2, Md all left side, dorsal aspect. Head, abdomen, A1 and A2-x15: UL, LL, Md, Mx1, Mx2-x50: Mxpd-x40: Mxpd(p)-x40: P11, P12-x75; P13-x100: Ep 1-3-x30: Tel-x50.

shorter third) plumose setae, with thicker proximal and thinner distal portions. Second pleopod like that of adult, or peduncle very short, outer margin slightly concave, bearing two coupling spines; a one-segmented ramus present, with one long apical plumose seta. Third pleopod a minute stump as in adult specimens.]

Uropod 1, peduncle long, slender, with two subterminal spines, interramal spine long, simple. Rami slender, shorter than peduncle, inner with two marginal spines, outer smooth. Uropod 2, peduncle as long as rami, with two spines near distal end; inner ramus with one marginal spine, outer ramus smooth. Uropod 3 very small, peduncle short, bearing one large lateral spine and several spinules, ramus small, conical with one small and one minute apical spine. Telson longer than wide, widening distally, apex rounded, slightly emarginate, one apical and five [up to five, usually four] marginal spines on each side.

Male

10.8 mm long. Like female, but bearing paired penes ventrally on segment 7 and lacking oöstegites.

Type material

Under leaf litter, *Atherosperma moschatum* stand, gully near Strickland Ave., foothills of Mt. Wellington, near Hobart. UGR 8312-213485 coll. JAF (J.A. Friend) 20/11/1977. Holotype ♀ 11.5 mm ovig. (three eggs), allotype ♂ 10.8 mm, paratypes 9 ♀♀ (1 ovig.) 11 ♂♂, five juveniles. Tasmanian Museum and Art Gallery nos. G1945-G1948. Under leaf litter, *Olearia argophylla* stand near Anglers Creek, off Tower Road, Tooms Lake area. UGR 8413-702229 coll. JAF 12/1/1976, one first instar juvenile. Tasmanian Museum and Art Gallery no. G1949.

Other material examined

Mt. Wellington, coll. E. D'Albertis and O. Beccari 12/2/1878, one specimen, Museo Civico di Storia Naturale, Genova. "Tasmania, old coll." 4 ♀♀ ovig. Australian Museum G5422. Lady Barron Falls, National Park, Tasmania, 19/1/1928, pres. G.P. Whitley, two specimens, South Australian Museum, TC902. Kingston, Tasmania, coll. C. Oke 14/5/1948, 2 ♂♂ 7 ♀♀ National Museum of Victoria.

Distribution

Recent collection has revealed that *T. vulgaris* n.sp. appears to be found in all parts of Tasmania, on Robbins, Schouten, Maria, Bruny and De Witt Islands, and on Ile de Golfe.

Remarks

The synonymies listed above were fairly easily proved. The types of *T. sylvaticus* and *T. kershawi* (registered in the Australian Museum, G5423, and the National Museum of Victoria, respectively) were examined for comparison. Thomson's figure 7 (1892) shows the distinctive sixth peraeopod gill of *T. vulgaris* n.sp. (which he refers to as "the branchiae of the fifth pair"), while his figure of the maxillipeds shows the outer plate with two distinct spine groups on the tips of the truncate apex, unlike the single spine group which is found apically on the sharply pointed outer plate of *T. sylvaticus*. Thomson apparently had more than one species present in his material; this is indicated by the other form of sixth peraeopod gill he describes, and the feathery pleopods figured, neither of which characterises *T. vulgaris* n.sp.

On examination, Ruffo's specimen proved to belong to *T. vulgaris* n.sp.: the distinctive third epimeral plate and fourth peraeopod gill, as well as the form of gnathopods, pleopods and telson, clearly indicated its identity. Hurley's figure

(1955) of the maxilliped of *"T. kershawi"* from Tasmania shows spination very similar to that shown here: in *T. kershawi* from Victoria, the maxilliped outer plate and palp, although similar in shape to those of *T. vulgaris* n.sp., are more spinous. Recent surveys have indicated that *T. kershawi* is absent from Tasmania.

Talitrus angulosus n.sp.
(figs 1, 4 and 5)

Description

Female

7.1 mm long. Head as long as deep, dorsal surface strongly rounded. Eye subcircular, small, about a quarter as wide as head is long. Antenna 1 very short, reaching only to one third length of distal peduncular segment; flagellum of four segments [3-5] much shorter than peduncle. Antenna 2 short, flagellum of 13 [8-16] segments, all bearing four groups of three spines, except proximal three (groups of two) and distal segment (one group of six); peduncle just shorter, distal segment shorter than penultimate two combined. Upper lip shallow, broad, apically pilose. Lower lip broad, inner shoulders pilose, sides of central trough lightly pilose. Mandible, incisor 3-toothed, left lacinia bicuspate, large cusp 4-toothed, molar process broad, accompanying setose spine large. Maxilla 1, inner plate short, inner margin proximally setose, outer plate, palp relatively large, 2-jointed, near midpoint of outer margin. Maxilla 2, outer plate the longer. Maxilliped, inner plate with inner margin pilose medially, and three setose spines distally; three terminal teeth, inner very small, outer tall; outer plate narrowing distally, apex truncate bearing spine groups at the corners (two spines on outer, four on inner corner). Palp slender, bearing a few long spines, fourth segment delimited proximally by a slight shoulder.

Gnathopod 1, coxal plate broad, almost square distally. Segment 2 broadening distally, poorly spined. Segment 4 longer than 3, bearing a shallow posterior lobe. Segment 6 fairly strongly spined posteriorly, narrowing distally, forming a simple hand with the strong dactyl. Gnathopod 2, coxal plate subsquare, distal margin evenly rounded, lightly spined; posterior process small, bluntly pointed. Gill large, with anterior and wide posterior extensions. Oöstegite entirely absent. Segment 2 linear, lightly spined with two or three larger spines proximally. Segment 4 subequal to segment 3, with large scabrous posterior lobe. Segment 5 equal to segment 6, expanded deeply posterodistally into a scabrous lobe. Segment 6 posterior surface rounded, dactyl well exceeded by apical lobe.

Peraeopods of medium length and stoutness, with larger spines bifid, especially on distal segments. Peraeopods 3 and 4, coxal plate shallow, broad, posterior process prominent, blunt. Gill of medium size, broadening posteriorly. Oöstegite short, linear, five [5-7] apical setae. Peraeopod 5, anterior coxal lobe shallow, lower margin oblique, lightly spinulose, posterior lobe smaller, shallow, posterior margin smoothly rounded. Gill small, convoluted, reduced oöstegite of gill-like texture, held laterally across ventral surface. Segment 2 relatively thin, narrowing distally, posterior margin gently convex, spinulose. Dactyl slender. Peraeopod 6, posterior coxal lobe deep, smoothly rounded distally; anterior lobe not so deep, rounded distally. Gill long, sinuous, convoluted proximally, then flattened, narrowing distally, with medial distal incision. Segment 2 sub-ovate, posterior margin bearing a few spines, distal lobe lacking. Segments 4 to 6 moderately spinose. Dactyl slender, terminal spine long. Peraeopod 7, coxal plate subrectangular, smoothly rounded posterodistally, with proximal anterior process. Segment 2 not very broad, posterior margin weakly serrulate, distal lobe absent. Segments 4-6 moderately slender and spinose, dactyl long and slender.

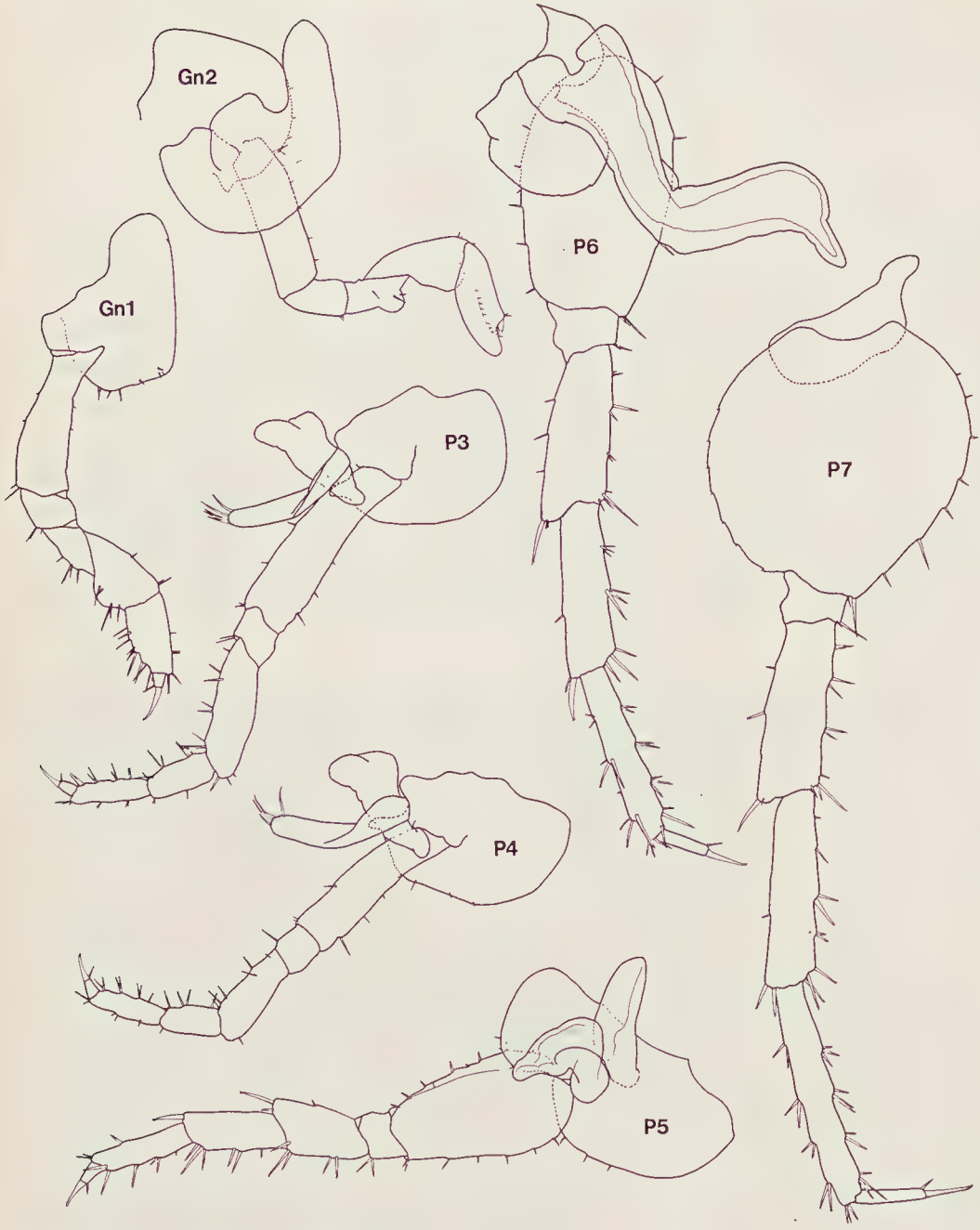


FIG. 4.- *Talitrus angulosus* n.sp., holotype ♀, 7.1 mm. A11 x 37.

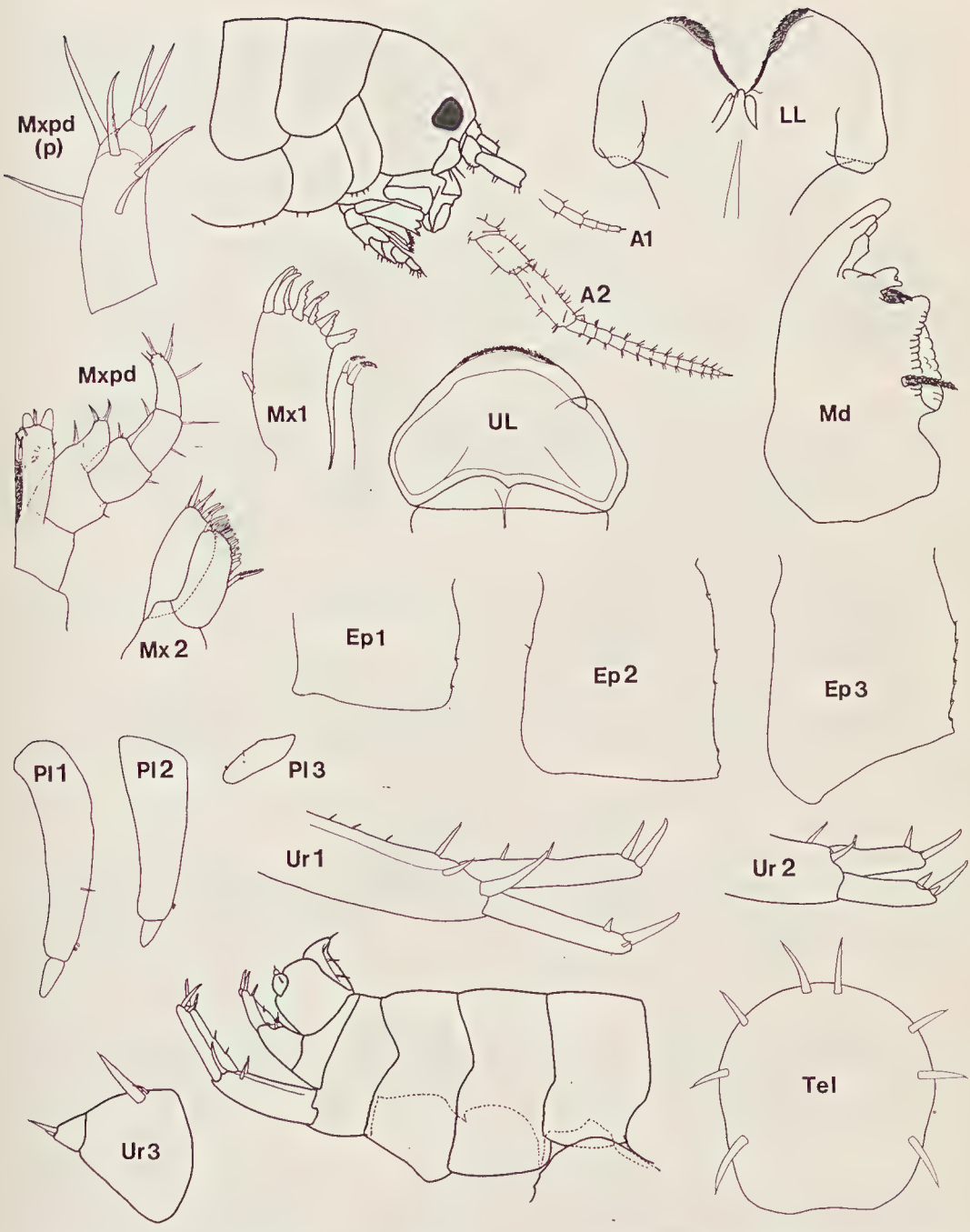


FIG. 5.- *Talitrus angulosus* n.sp., holotype ♀, 7.1 mm. Mxpd(p): distal portion, right palp of maxilliped, ventral view; Mx1, Mx2, Md all left side, dorsal aspect. Head, abdomen, A1, A2-x25: UL, LL, Md, Mx1, Mx2-x90: Mxpd-x75: Mxpd(p)-x225: Pl 1-3-x125: Ep 1-3-x45; Ur1, Ur2-x50: Ur 3-x115; Tel-x95.

First epimeral plate shallow, subsquare, posterior margin gently convex, bearing few serrations and spinules. Epimeral plate 2 subsquare, anterior margin bearing one small spine, anterior corner rounded. Posterior margin very weakly serrate and spinulose, posterior corner sharp. Epimeral plate 3 deep, well exceeding second plate. Lower margin excavate, oblique, anterior corner sharply rounded distally. Posterior margin weakly serrate and spinulose distally, proximally smooth.

Pleopods vestigial; peduncle of first short and slender, bearing a spine on the distal half, outer margin concave, inner margin with coupling spines. Ramus a terminal segment. Pleopod 2 similar but smaller and without subterminal spine. Pleopod 3 reduced to a small stump, bearing one subterminal spine and one coupling spine. [First instar specimens, South Coast population: pleopod 1, peduncle short, concave outer margin, inner margin with two coupling spines. Two rami present, outer longer than inner, both bearing two long plumose setae, equal in length to peduncle plus respective ramus. Pleopod 2 similar to pleopod 1 but half as long, ramal setae shorter proportionally. Pleopod 3 as in adult.]

Uropod 1, peduncle slender, bearing two subterminal spines, interramal spine long, simple, rami slender, as long as peduncle, inner bearing two marginal spines, outer smooth. Uropod 2, peduncle as long as rami, with two distal spines, inner ramus with one marginal spine, outer ramus smooth. Uropod 3 very small, peduncle short, bearing one large and one very small lateral spine, ramus small, conical, with one small and one minute apical spine. Telson short, broad, apex broadly rounded, entire; one apical and three [up to four, usually three] marginal spines each side.

Male

6.3 mm long. Like female, but bearing paired penes ventrally on segment 7 and lacking oöstegites.

Type material

Under litter, *Olearia argophylla* stand near Anglers Creek, off Tower Road, Tooms Lake area. UGR 8413-702229 coll. JAF 12/1/1976. Holotype ♀ 7.1 mm (ovig.) allotype ♂ 6.3 mm paratypes 19 ♀♀ (2 ovig.) 5 ♂♂ six juveniles. Tasmanian Museum and Art Gallery nos. G1950-G1952.

Other material examined

Under *Anopterus glandulosus* litter beside South Coast Track, top of high bank above east end of Prion Beach, south coast of Tasmania. UGR 8210-682786 coll. JAF 29/12/1976, 75 specimens. In soil and litter under eucalypt, tea-tree and blackwood trees beside Emu River, Burnie, North-West Tasmania. UGR 8015-094521 coll. JAF 28/7/1975, 23 specimens.

Distribution

Found in two apparently separate areas of Tasmanian mainland: in the north from the west coast near Temma, north of the Central Plateau, to the east coast at Ansons Bay and in an eastern strip south to Orford; and near the south coast, between New River Lagoon and South East Cape.

DISCUSSION

The species described herein have been allocated to the genus *Talitrus*, which, following Hurley (1955), includes all non-sexually-dimorphic terrestrial talitroid amphipods described to date. I support the view of Bousfield (1956) and Bousfield and

Carlton (1967), that the supralittoral *Talitrus saltator* (Montagu) should be separated generically from the terrestrial species, and that this can be done on morphological, and not simply ecological, grounds. However, rather than setting up or resurrecting a genus at this stage to receive these species, I prefer simply to point out their affinities within the current grouping.

T. kershawi Sayce, which occurs in southern and eastern Victoria (Sandell, 1977) falls into a natural group with the two species described here, as they share the following distinctive combination of features:

Maxilliped	:	Outer plate arcuate with truncate apex bearing a spine group at each corner.
Gnathopod 1	:	Segment 5 short and deep. Segment 6 proximally expanded.
Gnathopod 2	:	Segment 2 anterior margin bearing several large spines. Oöstegite absent.
Peraeopod 5	:	Oöstegite does not hold eggs against ventral surface of amphipod.
Peraeopod 6	:	Gill long, distally tapering.
Epimeral plate 3	:	Concave distal margin.
Pleopods 1 and 2	:	Reduced, usually bearing one or two ramal vestiges.
Pleopod 3	:	Reduced to a vestigial stump.
Pleopods	:	First instar young tend to bear long plumose setae on some pleopods.

Hurley (1975) has initiated the subdivision of the entire genus *Talitrus* by proposing eight subgenera. One of these, *Keratroides*, a monotypic subgenus comprising *T. kershawi*, is defined by some of the above characters, and would include *T. angulosus* n.sp. and *T. vulgaris* n.sp., provided several modifications of Hurley's definition are made. *T. vulgaris* n.sp. has no coupling hook on pleopod 3, and up to 5, not three pairs of marginal spines on the telson. I also find the above description of the distal end of the maxilliped outer plate more accurate than "relatively sharply pointed".

The three species may be separated by use of the following key. Table 1 includes further features in which the species differ.

Key to *Keratroides* Group

1 Third epimeral plate, anterodistal corner rounded ..... *T. vulgaris* n.sp.
Third epimeral plate, anterodistal corner sharp 2

2(1) Second antenna longer than head and first five body segments, dorsal surface of head gently curving anteriorly, body pigmented ..... *T. kershawi* Sayce
Second antenna not longer than head and first three body segments, dorsal surface of head strongly rounded anteriorly, body lacking pigment ..... *T. angulosus* n.sp.

While *T. vulgaris* n.sp. is fairly easily separated from the other two species, *T. kershawi* and *T. angulosus* n.sp. are very close in form and spination of appendages such as the form of third epimeral plate, third pleopod and telson spination, which are generally regarded as significant characters. They differ in more superficial characters, like colour, body size and relative size of appendages. However, I am separating these species because the variation of the appendage ratios does not overlap (there are differences between the species type collections in all three statistically treated parameters, at the 0.1% level) and because the overall impressions of the two groups of animals caused by their superficial differences are so distinct. Their taxonomic closeness must indicate that *T. kershawi* and *T. angulosus* n.sp. are recently derived from a common ancestor. This, coupled with their

TABLE 1

Comparison of type material

	T. kershawi Sayce	*T. angulosus* n.sp.	*T. vulgaris* n.sp.
Number of specimens	32	30	24
Ratio of eye width to head length ± S.D.	0.36 ± 0.02	0.24 ± 0.02	0.29 ± 0.08
Length of antenna 2	= head + 5-7 body segs. (5.6 ± 1.2)	= head + 2-2½ body segs. (2.1 ± 0.3)	= head + 4-5½ body segs. (4.5 ± 0.7)
Ratio of length of Pr 5 (segs. 2-6) to body length ± S.D.	0.60 ± 0.06	0.50 ± 0.03	0.57 ± 0.54
Greatest body length (all material)	16 mm	10.5 mm	15.5 mm
Number of antenna 2 flagellum segments, instar 1 (not types)	11	8	8
Telson: marginal spines each side	3 (2-4)	4 (3-5)	3 (2-4)
Egg numbers	?	1-6	1-10
Pigmentation of body	normal,brown	lacking	normal, brown to black

distribution on either side of Bass Strait (and the presence on a number of Bass Strait islands of a form resembling them), would support the contention that this ancestor was distributed across the Bassian isthmus during the Late Pleistocene lowering of sea level.

Preliminary observations of *T. vulgaris* n.sp. and *T. angulosus* n.sp. in the field and in the laboratory indicate ecological differences where these species are sympatric (Friend and Richardson, in press). The morphological differences outlined here are consistent with field observations that *T. angulosus* n.sp. is found deeper in the soil during the day, and moves less freely on the surface at night, than *T. vulgaris* n.sp. Lack of surface pigmentation and eye reduction are features found in animals of the deeper soil layers (Kuhnelt, 1976, pp.249-250) while smaller overall size and relatively shorter appendages would appear to equip an animal better for pushing through soil spaces. A consequence of the smaller size of *T. angulosus* n.sp. is a smaller brood size which could reduce breeding potential. On the other hand, *T. angulosus* n.sp. young are released at a smaller size than those of *T. vulgaris* n.sp. despite the increased danger of desiccation, so it is highly probable that the more stable soil environment enhances survival of young in the soil-dwelling species. Observations made during recent collection of *T. kershawi* near Melbourne indicated that this species resembles *T. vulgaris* n.sp. rather than *T. angulosus* n.sp. in its choice of microhabitat.

Both of the new species were found to bear bifid spines on peraeopods 3 to 7, segments 4 to 6, on all uropods and on the telson. In *T. vulgaris* n.sp. they occurred also on segments 2 and 3 of peraeopods 3-7. These spines have been drawn in many descriptions of talitrid amphipods, mentioned in a few (e.g. Hurley 1957: "bifurcated spines" and "bifurcate-tipped spines") and have appeared in Dahl's scanning electron microscope study (1973) of probable chemosensory receptors in this amphipod group.

Bifid spines distinguishable at the light microscope level must correspond only to the type mentioned by Dahl in which the hair is significantly longer than its protecting spine-tip, rather than to all the spine-hair types he named. However, the occurrence of such spines is noted here, as their presence or absence in talitrid species may prove to be important in phylogeny, or in relation to the particular adaptations of those species.

The *Keratroides* group of land-hoppers displays a number of advanced morphological features. The distinctive third epimeral plates of *T. kershawi* and *T. angulosus* n.sp. are highly modified from the talitrid type, but the causes of this are unclear. Perhaps the most significant features are the greatly reduced pleopods and the enlarged gills on both gnathopod 2 and peraeopod 6. Marsupium young of *T. vulgaris* n.sp. and *T. kershawi* possess biramous first and usually second pleopods bearing two long plumose setae terminally on each ramus (see Fig. 3: 2 Pl. 1). These setae have disappeared by the time the young have increased their second antennal segment number: there are indications that they are lost even before the first moult. In *T. angulosus* n.sp. this phenomenon has been noticed in only a few individuals from the south coast population. No north-western marsupium young have been examined and in the considerable number of east coast marsupium young examined, none has been found with these pleopod rami. Most probably, this pleopod form acts to enhance aeration of the gills of the young in the confined marsupium.

Special marsupium formation also points to the advanced state of this group. The oöstegites usually found on gnathopods 2 are entirely absent, while those on peraeopods 5 lack terminal setae and are held close to the ventral surface, rather than folding out around the eggs in an ovigerous female. Thus only two pairs of oöstegites on peraeopods 3 and 4 hold the eggs in place in these three species, although the fifth peraeopod oöstegites probably prevent the eggs from slipping out posteriorly from the marsupium. In another, as yet undescribed, Tasmanian species I have found a sperm mass held in place on the ventral surface of a non-ovigerous female by a similar pair of oöstegites, so it is likely that this form of posterior oöstegites in the *Keratroides* group is associated with modifications to the fertilisation process.

ACKNOWLEDGEMENTS

I should like to thank Drs. A.M.M. Richardson and J.L. Hickman (Zoology Department, University of Tasmania) both for their encouragement and for critically reading this manuscript. Financial support through a Commonwealth Postgraduate Research Award is gratefully acknowledged.

REFERENCES

Bousfield, E.L., 1956: Distributional ecology of the terrestrial Talitridae (Crustacea: Amphipoda) of Canada. *Proc. 10th Int. Cong. Entomol., 1:* 883-898.

_____ and Carlton, J., 1967: New records of Talitridae (Crustacea: Amphipoda) from the Central California coast. *Bull. S. Calif. Acad. Sci.*, 66(4): 277-284.

Bulycheva, A.I., 1957: Morskie blokhi morey SSSR i sopredelnykh vod (Amphipoda: Talitroidea). Opred. po faune SSSR. *Akad. Nauk. SSSR, Zool. Inst. Izd.*, 65: 1-186.

Dahl, E., 1973: Presumed chemosensory hairs in talitrid amphipods (Crustacea). *Entom. Scand.*, 4(3): 171-180.

Friend, J.A. and Richardson, A.M.M., (in press): A preliminary study of niche partition in two Tasmanian terrestrial amphipod species. in Lohm, U. and Persson, T. (Eds): SOIL ORGANISMS AS COMPONENTS OF ECOSYSTEMS. *Proc. VI Int. Soil Zool. Coll. Ecol. Bull. (Stockholm)*, 25: (1977).

Haswell, W.A., 1881: On some new amphipods from Australia and Tasmania. *Proc. Linn. Soc. NSW*, 5: 97-105.

_____, 1885: Notes on the Australian Amphipoda. *Proc. Linn. Soc. NSW*, 10: 95-114.

Hunt, O.D., 1925: On the amphipod genus *Talitrus* with a description of a new species from the Scilly Isles, *T. dorrieni* n.sp. *J. Mar. Biol. Assoc. U.K.*, 13: 854-868.

Hurley, D.E., 1955: Studies on the New Zealand amphipodan fauna No. 8. Terrestrial amphipods of the genus *Talitrus* Latr. *Pacific Science*, 9: 145-157.

_____, 1957: Terrestrial and littoral amphipods of the genus *Orchestia*, family Talitridae. *Trans. R. Soc. N.Z.*, 85(1): 149-199.

_____, 1975: A possible subdivision of the terrestrial genus *Talitrus* (Crustacea Amphipoda: family Talitridae). *N.Z. Oceanogr. Inst. Rec.*, 2(14): 157-170.

Kuhnelt, W., 1976: SOIL BIOLOGY, WITH SPECIAL REFERENCE TO THE ANIMAL KINGDOM. Second Edition. Faber and Faber, London.

Ruffo, S., 1949: Studi sui Crostacei Anfipodi 18. Gli Anfipodi del Museo civico di Storia naturale di Genova. Anfipodi di Sumatra, Celebes, Nuova Guinea, Australia e Tasmania. *Ann. Mus. civ. Stor. nat. Genova*, 63: 205-217.

Sandell, R.D., 1977: Some comments on Victorian landhoppers. *Vict. Nat.*, 94: 72-74.

Sayce, O.A., 1909: Description of two terrestrial species of Talitridae from Victoria. *Proc. R. Soc. Vict.*, 22(N.S., 1): 29-34.

Thomson, G.M., 1892: Notes on Tasmanian Crustacea with descriptions of new species. *Pap. Proc. R. Soc. Tasm.*, (1892): 43-76.

Papers and Proceedings of the Royal Society of Tasmania, Volume 113, 1979

(ms. received 9.1.1979)

OBSERVATIONS ON SOME TASMANIAN FISHES : PART XXV

by E.O.G. Scott
Launceston

(with six tables)

ABSTRACT

SCOTT, E.O.G., 1979 (20 vii): Observations on some Tasmanian fishes : Part XXV. *Pap. Proc. R. Soc. Tasm.*, 113: 99-148. ISSN 0080-4703. 82 Penquite Road, Launceston, Tasmania, Australia.

Five species are for the first time recorded from Tasmania; in each case some observations are made on the material, the chief points commented on here noted in parentheses.
CHAULIODIDAE - *Chauliodus sloani* (dentition, general features): IDIACANTHIDAE - *Idiacanthus fasciola* (specimen from gut of *Hyperoglyphe antarctica*); *I. niger* (type locality of synonymic *I. aurora*, Macquarie Island, part of a Tasmanian municipality): EMBIOTOCIDAE - *Diretmus argenteus* (juvenile characters): CARANGIDAE - *Trachurus mccullochi* (key to Tasmanian carangids): ANTHIIDAE - *Hypoplectrodes nigrorubrum* (additions to, revision of, published accounts, key to Tasmanian anthiids).

Observations are made also on the following species:-
MACROURIDAE - *Coelorinchus mortoni* (new material of little-known species); *Lepidorhynchus denticulatus* (food of *Rexea solandri*, abnormal spinous structure); *Macruronus novaezelandiae* (fluviatile example): SYNGNATHIDAE - *Solegnathus fasciatus* (sex dimorphism, relative growth, table of dimensions); *Stigmatophora argus* (comparison with published data). *Syngnathus phillipi* (proportions): SPHYRAENIDAE - *Australuzza novaehollandiae* (food of seal, proportions): SCOMBRIDAE - *Gasterochisma melampus* (additional Tasmanian record): ANTHIIDAE - *Anthias pulchellus* (second Tasmanian record, extension of extant accounts). *Caesioperca rasor* (examination of 11 examples, table of dimensions); *Caesioperca lepidoptera* (additions to published accounts); *Callanthias allporti* (additions to, revision of, published descriptions): ECHENEIDAE - *Remora remora* (comparison with larger examples reported on earlier).

In the case of several species the existence of one or both of two interesting form patterns has been examined: (a) length of head, length to vent, standard length are found to be collinear in a loglog plot on integral numbers, (b) the lengths of spines and rays, in one or more sets, are found to yield a linear graph when plotted on a loglog grid against their serial (or reverse serial) numbers.

INTRODUCTION

This paper follows the general plan of others in the series. Linear measurements are given throughout unless otherwise specified in millimetres, the name of the unit commonly being omitted. The symbols *Ls*, *Lt*, *TLs*, *TLt* denote standard length, total length, thousandths (permillages) of standard length, thousandths of total length, respectively. Registration numbers denoted by Q.V.M. are those of the Queen Victoria Museum and Art Gallery, Launceston. Certain other conventions are noted in earlier contributions.

Observations on some Tasmanian Fishes : Part XXV

FAMILY CHAULIODIDAE

No representative of this group of deep-sea fishes has hitherto been met with in Tasmanian waters, the sole account in the literature of an Australian form being based on *Endeavour* material taken off the coast of Victoria, described by McCulloch (1916) as an indigenous species, *Chauliodus dannevigi*, now generally regarded as synonymic with the long-known extralimital *C. sloani* Bloch & Schneider, 1801, a species now added to our local list.

Genus *CHAULIODUS* Bloch & Schneider, 1801

Chauliodus Bloch & Schneider, 1801, SYST. ICHTHYOL., p.430. Type-species, *Chauliodus sloani* Bloch & Schneider.
Leptodes Swainson, 1839, NAT. HIST. CLASSIF. FISH. AMPHIB. REPT. (CABINET CYCLOPAEDIA, 2), p.298. Type-species, *Leptodes sloanii* (Bloch & Schneider).

Chauliodus sloani Bloch & Schneider, 1801

Chauliodus sloani Bloch & Schneider, 1801, SYST. ICHTHYOL., p.430.
Chauliodus dannevigi McCulloch, 1916, BIOL. RES. ENDEAVOUR, 4(4), p.179, pl.52.
Type locality: Off Cape Everard, Victoria.
Chauliodus dannevigi: Munro, 1957, HANDBK AUST. FISH., 7, p.30, fig.210.

Tasmanian record

A partly digested specimen of a *Chauliodus* in two pieces was collected, 1-17 December 1977, by Mr John Head 27 km east-south-east of Tasman Island from the stomach of a deep-sea trevalla (this species appears in almost all Australian texts as *Hyperoglyphe porosa* (Richardson, 1845); however the synonymization of Richardson's fish with *H. antarctica* (Carmichael, 1818) proposed by Haedrich (1967) is now increasingly becoming accepted), taken in 460-550 m. Accompanying this specimen were two myctophids (forwarded to Dr J.R. Paxton, the Australian Museum Sydney, who has published on the Myctophidae, and is at present researching the Australian representatives), together with two unidentified and probably unidentifiable fragments.

Specific status

In his review of the Chauliodidae Baird (1973, p.279) concluded that of more than a dozen nominal species of *Chauliodus* only six are valid, *C. sloani* Bloch & Schneider, 1801, *C. macouni* Bean, 1890, *C. pammelas* Alcock, 1892, *C. barbatus* Garman, 1899, *C. danae* Regan & Trewavas, 1929, *C. schmidti* Ege, 1948. In describing *C. dannevigi* McCulloch (1916, p.179, pl.52) noted some minor differences between his material, a specimen 'nearly 200 mm' in length, taken by the *Endeavour* in 330-440 m 50 km south of Cape Everard, Victoria and the descriptions of the first three of these species (and of two nominal species). However, *C. dannevigi* is now regarded as a junior synonym of *C. sloani*.

While the present specimen is not in a sufficiently good state of preservation to permit of definitive specific determination, it would appear rather clearly to be identical with the fish described by McCulloch as *C. dannevigi*, i.e., *C. sloani;* on the available morphological evidence, reinforced by geographical considerations it is here referred to that species, the only one reported from our region (Munro, 1957a).

Description

(i) General. The recovered material comprises (a) head and anterior part of trunk ending in the vicinity of the pelvic base, total length 82 mm, from tip of upper jaw 76; (b) a second portion apparently continuous or subcontinuous with the first, 68 mm long, extending beyond the base of the rayed anal by approximately the length of the base.

Only scattered vestiges of the black integument remain intact, virtually the whole surface in both sections being stripped to the off-white flesh. There are thus lacking all photophores, on the number and distribution of which the key to species provided by Baird is mainly based. No fins are present. However, the locations of the dorsal and the rayed anal are made evident by what are clearly the persistent remnants of their bases. As figured by McCulloch (1916, pl.52) the dorsal base is distinctly elevated above the immediately adjacent profile: no fin rays remain but about half a dozen rounded prominences apparently represent the ends of the pterygiophores. The length to the base from tip of upper jaw (23 mm) is 1.9 times length to preopercular border (12), the base (6.5) being 3.5 in length to its commencement; both ratios being about equal to the corresponding values as estimated from McCulloch's plate. The base of the anal (all of the fin that remains) like that of the dorsal is elevated: about 12 rather stout subcylindrical projecting pterygiophores can be counted. The length of the base (11) is 1.1 (in good agreement with about 1.2 in McCulloch's illustration) times length from tip of upper jaw to preopercular border; or 10.0 (*cf.* McCulloch's figure about 11.5) in length to base. Six, possibly seven, short fine processes occupying the ventral profile between 64 and 67 mm from tip of upper jaw probably represent the bases of the pelvic rays; their distance from presumed dorsal termination is 1.25 (*cf.* about 1.32) times length from tip of upper jaw to dorsal termination. The hind portion of the head and the region immediately beyond it have been subject to some local displacement; however, a curved gelatinous ridge consisting of about a dozen vertically elongate segments and rather more than an eye diameter in length, located on the right side below and behind the operculum, is very probably the right pectoral base; a similar structure with its origin at a corresponding point on the left side, but dislodged so as to extend across the midventral line and to terminate almost in contact with the right-hand structure, would seem clearly to represent the left pectoral base. No trace can be found of either the adipose dorsal or the adipose anal. The somewhat ridged obscurely crenulate triangular posterior end of the second segment of the fish may represent the base of the caudal.

(ii) Proportions. McCulloch noted several body ratios for the type-specimen of *C. dannevigi*. Seven items for which an estimate for our specimen can be made (two relative ray lengths omitted) are here noted (McCulloch's values in parentheses). Head from premaxillary symphysis to end of operculum 9 (7.6) in *Ls*. Greatest depth of head 1.1 (almost equal to) head length. Depth of body anterior to dorsal 1.7 (1.4) in head. Eye 1.04 (equal to) snout, 3.2 (4.2) in head. Pectoral-ventral interval 0.9 (1.5) in ventral-anal interval, 3.1 (2.7) in length from end of operculum to hypural. Base of anal 1.5 (1.6) in head. The most marked discrepancies involve the relatively greater anal-ventral interval in the *Endeavour* fish: possibility that a short section between the two segments of our fish is missing cannot be dismissed.

(iii) Dentition. While the large anterior teeth present a more or less constant pattern, the other teeth exhibit some variation on the two sides of the jaw. Premaxillary fangs four on each side; four evenly spaced, first a little longer than fourth, slenderest, subcylindrical except proximally, here expanded vertically and compressed laterally, with a shallow groove in proximal one-third of inner surface; second longest, somewhat flattened, sabre-like, with a short downwardly and forwardly oblique elongated triangular element constituting tip; third and fourth much like second but smaller, fourth the longer, somewhat more backwardly directed: additional teeth on left side, one situated somewhat internad of, and anterior by less than its own width to, second normal tooth; one very small curved about midway between second and third fangs but inserted somewhat externad of these; two small teeth or tooth-like projections arising from a small bony lamella near base of third fang: on right side an additional tooth arising at base of fourth fang, subequal in length to this but much more slender, directed backward at an angle of about 60° to it so that it comes to lie along anterior portion of the row of small maxillary teeth with which it is nearly in contact. Anterior edge of maxilla almost wholly occupied by a row of

closely set very small backwardly directed teeth; on left side 31, increasing in length backward to the last half dozen, odd-numbered teeth (counting from most anterior) distinctly shorter than even-numbered; on right side a similar but less well preserved series, in the anterior portion the distinction in size between alternate teeth somewhat less pronounced than on left.

Mandibular series on left side of six, first very large almost twice length of longest premaxillary fang, approximating total length of head, second less than one-third as long, third strongly recurved, about twice length of second, rest small weak decreasing in size backward, last less than 1 mm; similar series on right side together with a microscopic seventh tooth.

On right side three small recurved teeth, their heights a little greater than the intervals between them, occur on the floor of the mouth at the level of the hinder part of the maxillary tooth-line, together with one large erect tooth slightly in advance of level of fourth fang; on the left side, which is somewhat crushed, only the isolated anterior tooth is detectable.

Family IDIACANTHIDAE

The family Idiacanthidae (including Stylophthalmidae, Stylophthalmoidae based on the remarkable stalk-eyed larval form originally described as a distinct species) is represented by a single cosmopolitan genus, *Idiacanthus* Peters, 1876, usually found at great depths. Of a small number of species described at most three probably only two are valid (Smith 1970), *I. niger* Regan, 1914, *I. fasciola* Peters, 1876, *I. atlanticus* Brauer, 1906, the third not improbably a synonym of the second. The Handbook (Munro 1957a, p.300, fig.212) lists *I. fasciola* from off Northern Australia and (p.301, fig. 213) *Stylophthalmus paradoxus* Brauer, 1903, 'presumably the larval form of the preceding species' from oceanic depths off New South Wales: Dr J.R. Paxton informs me the Australian Museum has recently taken adult *I. fasciola* off southern New South Wales. There have been no formal records for Tasmania of an idiacanthid (see, however, note below on a record of *I. aurora* Waite, 1916, a synonym of *I. niger* Regan, 1914, from Macquarie Island).

Genus *IDIACANTHUS* Peters, 1876

Idiacanthus Peters, 1876, *Monatsb. Akad. Wiss.* Berlin, p.846 [dated 1877, issued December 1876]. Type-species, *Idiacanthus fasciola* Peters.
Bathyophis Günther, 1878, *Ann. Mag. Nat. Hist.*, (5), 2, p.181. Type-species *Bathyophis ferox* Günther.

Idiacanthus fasciola Peters, 1876

Idiacanthus fasciola Peters, 1876, *Monatsb. Akad. Wiss.* Berlin, p.846. Type locality: northward of Australia, 117°E, and New Guinea, 136°E, 104'S (2 specimens, both at surface).
Bathyophis ferox Günther, 1878, *Ann. Mag. Nat. Hist.*, (5), 2, p.181. Type locality: middle of North Atlantic, *Challenger* Station 63, 2750 fathoms (3520 m).

Tasmanian record

An example of approximate total length 155 mm from the stomach of a deep-sea trevalla, or bream trevalla, *Hyperoglyphe antarctica* (Carmichael, 1818) — appears in the Handbook and in most Australian texts as *Hyperoglyphe porosa* (Richardson, 1845), of which *Eurometopus johnstonii* Morton, 1888, with Tasmania as type locality, is a synonym — taken 30 km east-south-east of Wineglass Bay (Thouin Bay), east coast, 12 July 1978 by Mr John Head; Q.V.M. Reg. No. 1978/5/33.

Specific determination

In view of the circumstances of its collection the specimen is expectably not in very good condition. Part of the head including almost the whole of the upper jaw in advance of the eye is lacking; the caudal fin is missing and it is possible there is some further loss in this region, though the general form, the sectional vertebral counts and the relative positions of the insertions of the fins combine to suggest that if such is the case the loss is a minor one; the dorsal and anal fins have suffered considerable damage. Throughout the length of the fish the flesh is closely adherent to the vertebrae, the outlines and in parts the actual surfaces of which are evident; however, this condition is not wholly attributable to the effects of digestive processes, it having been noted by Günther (1887, p.216) of the *Challenger* specimen of the synonymic *I. ferox* that it had "the muscular system so little developed that in its present preserved state the vertebral column appears to be merely covered by the skin, with the outlines of the vertebrae clearly visible."

Though the dorsal fin is imperfect and its forward extension somewhat doubtfully determinable, it would seem to be traceable for two possibly three vertebrae in advance of the well preserved ventrals — the sole criterion employed by Smith (1970, p.101) in his key to the genus *Idiacanthus* to distinguish *I. fasciola* and *I. atlanticus* together from *I. niger*, in the last-named ventral origin being in advance of dorsal origin. The distinction between *I. fasciola* and *I. atlanticus* rests on the number of photophores of the VAV series extending from ventral origin to vent (15-18, 22); unfortunately few of the photophores are here recognizable. In view of the reasonably likely exclusion of *I. niger* by the dorsal-ventral relation, of the dubious systematic status of *I. atlanticus* and its limited established distribution (west coast of South Africa), and of the known occurrence of *I. fasciola* in most, including Australian, seas, the specimen is here provisionally ascribed to the last-named species.

General observations

Extremely attenuate, band-shaped, the head relatively large and deep, its length equalling or exceeding that of trunk immediately behind, trunk thereafter decreasing slowly in height posteriorly, a process continued throughout length of tail. Ventrals preserved but locations of dorsal and anal origins somewhat conjectural: as measured, the origins at 323, 338, 667 *TLt* units from tip of lower jaw; approximate corresponding values estimated from the illustration by Günther (1887, pl.52, fig.D) of his *I. ferox (= I. fasciola)* 340, 340, 640. Ventrals inserted on 20th (Günther 22nd) vertebra behind head, vertebrae between ventral and anal origins 16 (17), remaining vertebrae 19 (20), total 55 (59). The count of 19 preventral vertebrae has been made from level of obvious end of inferior profile of head; however, in a curious extension the vertebral column extends forward of this point constituting present dorsal profile for 12 mm in the form of 9, possibly 10, compressed centra, reaching to within 2-3 mm of eye or about to level of middle of intact lower jaw. Vertebrae of trunk hourglass-shaped, anteriorly about twice as long as deep, posteriorly somewhat shallower. Dorsal and anal rays simple, very slender, each inserted at the anterior end of a vertebra, subequal in length to it; no remaining traces of fin membranes. A series of short stout slightly recurved spines, one in front of each dorsal ray, modally inserted on elevated ring at junction of adjacent vertebrae and then immediately at base of ray, occasionally at some little distance from junction. Ventral with 6 simple rays, relatively elongate, slender, length about 12 mm, extending over two and a half centra.

Ventral profile of head descending abruptly near middle of jaw and extending well behind level of gape as a pronounced subhorizontal ridge, its maximum depth about twice that of jaw proper. Barbel originating on knob at anterior end of keel, as preserved 68 *TLs* (18 mm) long, filamentous. Teeth mostly large or largish, slender, straight or slightly suddenly recurved distally, depressible. In lower jaw on left side 22 main teeth in 4 sets as follows, 5 increasing in size backward, last 3 mm about five times

first, 6 increasing in size backward last 4 mm, 4 increasing very slowly backward to third 1.5 mm, followed after a short diastema by 4 very small decreasing in size backward, largest 0.3 mm last minute: inserted externad of first set 2 very small, of second set 5 small, of third set 2 very small. A generally similar arrangement on right side with, from front, primary sets of 5, 4, 3, 4, together with 6 small teeth set outside the rest.

Whole fish including inside of mouth black, ventral rays black, dorsal and anal rays dark brown proximally lighter distally; exposed vertebrae whitish or yellowish.

Idiacanthus niger Regan, 1914

Idiacanthus niger Regan, 1914, *Ann. Mag. Nat. Hist.*, (8), 15, p.14. Type locality: New Zealand *(Terra Nova)*.
Idiacanthus aurora Waite, 1916, *Sci. Rept Aust. Antarct. Exped.*, 3(1), *Fish.*, p.53, pl.5, fig.1 and text fig.11. Type locality: Off Macquarie Island, 145-636 fathoms (2650-1160 m).

Remarks

From time to time writers have included in New Zealand faunal surveys fish collected at such subantarcitc localities as the Campbell Islands, Auckland Islands, Macquarie Island; such is the case with the present species in the shape of the synonymic *I. aurora* described by Waite (1916) from the last-named locality, a record entered in the check-list of fishes recorded from the New Zealand region by Whitley (1968, p.21). Situated in 158.58 E, 59.29 S, Macquarie Island is zoogeographically in the subantarctic region; at the same time it is in terms of political geography part of Tasmania being included in the municipality of Esperance. It is perhaps appropriate to draw attention here to the ambivalent locality-status of *Idiacanthus niger*.

For a note on a similar situation involving the sleeper shark, *Somniosus antarcticus* Whitley, 1939, known only from Macquarie Island, see Part XXII (1976, p.160).

Family MACROURIDAE

The family name Macrouridae is here adopted in line with the recommendation of Greenwood *et al.* in their general classificatory scheme (1966); common alternatives that have been employed in Australian texts are Macruridae, Macruroididae, Coryphaenoididae. The Australian species were keyed in Part XI (1953, p.150). Species credited to Tasmania in the Handbook (Munro 1957 b, c) are *Macruronus novaezelandiae* (Hector, 1871), *Lepidorhynchus denticulatus* (Richardson, 1846), *Coelorinchus australis* (Richardson, 1839), *C. fasciatus* (Günther, 1878), with *C. innotabilis* McCulloch, 1907, from Bass Strait; in Part XVII (1970) the writer suggested the rehabilitation of *C. mortoni* Ogilby, 1897, with Tasmania as type locality, early sunk in synonymy.

Genus *COELORINCHUS* Giorna, 1809

Coelorinchus Giorna, 1809, *Mem. Acad. Sci. Turin* (1805-1809), p.179. Type-species *Coelorinchus laville* Giorna. Variably spent by authors *Coelorhynchus, Coelorynchus, Coelorhincus*.

Coelorinchus mortoni Ogilby, 1897

Coelorhynchus mortoni Ogilby, 1897, *Pap. Proc. R. Soc. Tasm.* (1896), p.83. Type locality: Estuary of the Derwent River, Tasmania. Type destroyed (McCulloch, 1929, p.127).

Coelorhinchus australis: McCulloch, 1929, *Mem. Aust. Mus.*, 5(1), p.127, *partim.* Not *Lepidoleprus australis* Richardson, 1839 (type locality: Port Arthur, Tasmania).
Coelorhynchus mortoni: Scott, 1970, *Pap. Proc. R. Soc. Tasm.*, 104, p.38, fig.1.

Status

The history of Ogilby's species, described in this journal (1897), has largely been one of taxonomic neglect or rejection. Not noticed in the local lists of Lord (1923, 1927) and Lord & Scott (1924) and not represented in the key to the Australian and New Zealand species of the (relevant) subgenus *Paramacrus* as these are interpreted in the *Endeavour* Report it was relegated by McCulloch (1911, p.38) to the synonymy of *C. australis* (Richardson, 1839), a position maintained in the check-list (1929), and adopted also in the Handbook by Munro (1957 c). In Part XVII (1970) reasons were advanced for its recognition as a valid species, detailed descriptions of two complete specimens and a head being provided, together with figures (general view, dorsal surface of head, scale). No illustration was given by Ogilby.

Additional material

In June 1978 the Queen Victoria Museum received from Mr Shane Downe a specimen 396 mm in total length, slightly imperfect posteriorly, estimated intact length 410 mm (Reg. No. 1978/5/82). This species is readily recognizable by the presence of some eight or ten conspicuous white lines on the side, the middle three or four extending unbroken from shortly behind head to end of tail; these stripes are not found in *C. australis*, the only significant marking of which is a pair of oblique dark bars, one in front of first dorsal, the other below beginning of second dorsal. Mr Downe informs me it is not uncommon round about St Helens, east coast, even being exploited commercially there. The quantitative data on the earlier specimens given in table 3 in Part XVII are here supplemented by the meristic characters and principal dimensions of the present specimen. The relative lengths of the primary regions head trunk tail are also examined, and some length-number relations of fin rays are specified.

Meristic characters

D. II, 10; *ca* 79. A. *ca* 79. V. 7. P. 17. L. lat. *ca* 100 (imperfect distally). L. tr., from origin of first dorsal 4/1/15, from origin of second dorsal 4/1/9.

Dimensions as *TLs*

The estimated standard and total lengths of 405 410 are here and elsewhere adopted. Total length 1012. Length to origin, termination of first dorsal 249, 316, origin of second dorsal 353, origin of anal 338. Length to origin of pectoral 215, total length of fin 135, length of longest (3rd) ray 115. Length to origin of ventral 225, total length of fin 109, longest ray ('spine') 101 (for other rays see below). Length to middle of vent 331. Both dorsal spines damaged (for other first dorsal rays see below). Rays of second dorsal, 1st, 2nd, 3rd, middle, last preserved 22, 24, 25, 16, 17. Anal rays, 1st, 2nd, 3rd, middle, last preserved 56, 64, 67, 62, 62, 22. Head 212. Snout 62. Eye, horizontal diameter 67, vertical 49. Interorbital 63. Length to front, back of mouth 46, 53, width of mouth 96. Depth (width) at front of upper lip 75 (81), front of eye 86 (89), back of mouth 121 (107), back of eye 128 (111), operculum 153 (114), anal origin 133 (99); maximum 163 (114). Direct distance genal ridge to eye 23, to nostril 15; nostril to eye 5. Internarial 59. Interpelvic 52.

These relative dimensions are in general in good agreement with those recorded for the specimens in table 3 in Part XVII (1970), the present example showing somewhat greater values for length of pectoral, width of mouth.

Proportions

Values for 1970 specimens, *Ls* 508, 509, in parentheses. Maximum depth 6.1 (6.6, 6.6), depth at anal origin 6.8 (7.4, 7.6) in *Ls*. Head 4.7 (5.3, 4.8) in *Ls*. Snout 3.4 (3.3, 3.1) in head. Length to mouth 4.6 (5.3, 5.9), width of mouth 2.2

(3.0, 2.8) in head. Eye 1.1 (1.0, 1.0) snout, 1.1 (1.0, 1.1) interorbital. First dorsal base 15 (18, 15) in *Ls*, 3.2 (3.3, 3.2) in head. Pectoral 8.3 (9.3, 9.1) in *Ls*, 1.6 (1.7, 1.9) in head. Ventral 9.2 (11.0, 10.5) in *Ls*, 2.0 (2.1, 2.2) in head.

Ventral fin

While all the 7 ray elements of the ventral are conventionally regarded as rays, the preaxial element is of a somewhat anomalous nature, being in respect of its location the analogue of the spine in the modal, and probably basic, type of fin. Apart from its position it is here distinguished from the remaining elements in being somewhat more rigid (especially briefly proximally), unbranched, more or less ivory in color (rest of fin greyish), all spine-like attributes; on the other hand it is unspinelike in being the longest element of the series, its length being such as clearly to exclude it from the quite definite length-number pattern presented by the 6 other rays (all branched, modally with two successive divisions).

It is found these 6 elements increase exponentially in length with their serial number (extreme postaxial ray counted, in accordance with convention adopted in Part XIX (1974) as first, thus yielding, as for comparable formulations for other fins, a line with a positive slope). With lengths as millesimals of accepted standard length in a loglog plot on 1 2 3 4 5 6:

Log L = 0.2821 log N + 1.722; t = 11.522***; predicted (observed) lengths 53 (51) 64 (67) 72 (74) 78 (78) 83 (81) 87 (86).

In view of the recognition of this length-number pattern in the present specimen the comparable equations for the two 1970 examples have also been calculated, the parameters being 0.1615, 0.1973 and 1.7215, 1.6902, t 19.189***, 13.918***; percentage difference between given and estimated values being in specimen (a) 0.6 - 1.5 mean 0.7, in (b) 2.2 - 5.6 mean 3.9.

First dorsal

The 2 spines are imperfect and their length cannot be determined; in the 1970 examples the first is only 0.06, 0.05 of the second, the latter subequal to first ray. The 10 rays of the first dorsal decrease regularly in height backward, and it is found that when the logarithms of their lengths are plotted in reverse order of the rays on logs 1-10, a significant first degree equation is obtained. It has been thought of interest to carry out also for the dimensions of the earlier specimens given in table 3 of Part XVII (1970, p.43) the calculations made on Mr Downe's fish. The results are subjoined; all dimensions millesimals of standard length (405, 509, 508 mm): in 1970 (b) there is no entry for shortest (10th) ray (imperfect).

1978. Log L = 0.8195 log N^1 + 1.3088; t = 31.413***; calculated (measured) lengths 20 (22) 36 (35) 51 (49) 63 (59) 76 (73) 88 (83) 100 (104) 112 (117) 123 (132) 134 (136).

1970 (a). Log L = 0.8215 log N^1 + 1.3552; t = 32.818***; 23 (21) 40 (41) 56 (62) 71 (72) 85 (83) 99 (99) 112 (117) 125 (125) 138 (131) 150 (144).

1970 (b). Log L = 0.8677 log N^1 + 1.2676; t = 31.157***; - (-) 34 (34) 48 (51) 62 (57) 75 (73) 88 (85) 100 (104) 113 (116) 125 (128) 137 (133).

Head, head + trunk, head + trunk + tail

In a loglog plot these dimensions are found to be linear on 1, 2, 10. The recognition of this relation here has prompted the making the comparable calculations for the earlier specimens for which data are recorded in Part XIII (1970, table 3). For the present example the estimated standard length of 405 mm has been adopted (other lengths 509, 508). Length-number specifications are set out below, all lengths being in *TLs* units (given dimensions in parentheses).

1978. Log L = 0.6700 log N + 2.3222; t = 49.117*; 210 (212) 336 (331) 996 (1000).

1970 (a). Log L = 0.6858 log N + 2.3112; t = 40.387*; 205 (208) 329 (322) 999 (1000).

1970 (b). Log L = 0.7291 log N + 2.2701; t = 170.743**; 186 (187) 309 (307) 998 (1000).

Genus *LEPIDORHYNCHUS* Richardson, 1846

Lepidorhynchus Richardson, 1846, ZOOL. VOY. EREBUS AND TERROR, FISH., p.53. Type-species, *Macruronus vel Lepidorhynchus denticulatus* Richardson.
Optonurus Günther, 1867, REPT VOY. CHALLENGER, ZOOL., 22(57), pp. 124, 127. Type-species, *Optonurus denticulatus* (Richardson).

Lepidorhynchus denticulatus Richardson, 1846

Macruronus vel Lepidorhynchus denticulatus Richardson, 1846, ZOOL. VOY. EREBUS AND TERROR, FISH., p.53, pl.32, figs 1-3. Type locality : South Australia.

Remarks

This species does not rate a formal entry in either of the lists of Johnston, though in the addenda to the first (1883, p.143) in proposing his *Coryphaenoides tasmaniae (= C. novaezelandiae* Hector, 1871*)* he observes 'It is very probable that *C. denticulatus* Rich., which is found on the South Australian and New Zealand coasts, also inhabits Tasmanian waters'. In the lists of Lord and Lord & Scott it is referred to Günther's genus *Optonurus;* rather curiously the last-named work provides no express Tasmanian record, remarking only 'Specimens have been secured by trawlers in Bass Strait.'

A specimen obtained near St Helens, east coast, in September 1978 by Mr. Shane Downe (Q.V.M. Reg. No. 1978/5/98) is of some special interest on two counts, the circumstances of its collection and its possession of an unusual structure.

The fish, approximately 465 mm in total length, was found in the mouth of a *Rexea solandri* (Cuvier, 1832), taken at a depth of about 440 m. *R. solandri* (referred in the lists of Johnston to *Thyrsites* Cuvier, 1832, in later lists to *Jordanidia* Snyder, 1911), which appears in Australian works under various names, chiefly hake, king barracouta, kingfish (Tasmania; applied elsewhere to *Cybium commerson* Lacépède 1800, *Seriola grandis* Castelnau, 1872), now has the official vernacular name gemfish by decision of the Commonwealth Standing Committee on Fisheries (Anon. *in Australian Fisheries,* 1975, p.18), the use of any other name in merchandising being illegal in New South Wales. Though somewhat crushed, particularly about the head, the macrurid as recovered was intact overall, but it was not in good enough condition to permit of satisfactory detailed measurement.

The fish possesses an unusual structure in the shape of a strong supernumerary double spine at the front of the dorsal fin. This consists of two subparallel blade-like bony processes, compressed laterally, sharply pointed distally, directed backward and upward, their total length 10 mm, their bases about 1 mm apart set in two contiguous protuberances. The normal spines, of which there is the regular complement of 11, are also divided, their moities being side by side instead of as usual one behind the other.

Macruronus novaezelandiae (Hector, 1871)

Coryphaenoides novae-zelandiae Hector, 1871, *Trans. N.Z. Inst.*, 3, p.136, pl.18, fig.1. Type locality: Off Ward Island, Port Nicholson, New Zealand.
Coryphaenoides tasmaniae Johnston, 1883, *Pap. Proc. R. Soc. Tasm.* (1882), p.143. Type locality: Kangaroo Bluff, Tasmania.

Remarks

Johnston's species is undoubtedly conspecific with Hector's, with which his account suggests he was unacquainted. It occurs seasonally in schools on the west coast (Johnston, Lord & Scott *fide* Rodway), and is known at times to enter the Derwent

and Tamar rivers on the south and north coasts. Three examples, *Lt* 527 530 545 from Strahan, west coast, were examined in some detail in Part VI (1953, p.153). That account noted also an example, *Lt* 346, from the Tamar River at Beauty Point; a further example, *Lt* 425, taken much further up the river was dredged in 50 - 80 m at Deviot some 25 km from the sea on 16 September 1978 by Mrs Suitor (Q.V.M. Reg. No. 1978/5/102).

In meristic characters and in general form this fish exhibits no notable departures from the 1953 material; there are, however, some minor differences in proportion. There are here noted for the four ratios reported in the Handbook (Munro 1957) the present values followed in parentheses by the range for our earlier specimens and the single-value Handbook entires. Depth in total length 7.33 (7.07, 6.34 two examples only, 7.5). Head in total length 5.67 (6.06-6.39, 5.6). Head in trunk 1.63 (1.58-1.64, 1.6). Interdorsal in base of first dorsal 4.07 (4.89-6.17, 5.6).

Head, head + trunk, head + trunk + tail

As with *Coelorinchus mortoni* these dimensions are here linear in a loglog plot with three natural numbers. However, reflecting the noticeable differences in the relative locations of the three points the vent here comes closer to 5 than to 2½ the equation with abscissal values 1,5,10 reaching formal significance (t = 19.179) for this specimen but falling fractionally short of it (12.633) for the geometric mean of the three 1953 examples. The best fit is on 3,4,5 with t = 129.243**, 28.702*; slopes 3.3880, 3.5437, intercepts 0.6301, 0.5143, predicted (measured) values 176(177) 468(464) 996 (1 000) and (geometric means) 166(163) 444(429) 978 (1 000), all dimensions as *TLs*.

Family EMBIOTOCIDAE

In their provisional teleost classification Greenwood *et al.* (1966) recognize the Embiotocidae (sometimes rendered Ambiotocidae) as embracing Diretmidae Hysterocarpidae and Holconotidae. If the first of these is accepted as being of family status — as it is in the Handbook (Munro 1958 a) and as it continues to be by some overseas authors working on the group, e.g., Woods & Sonoda (1973), Post & Hecht (1972) — the fish here reported on is to be referred to it. No member of the Embiotocidae has previously been recorded from Tasmania, and the present species is the only Australian representative listed in the Handbook and the Check-list (McCulloch 1929). I am indebted to Dr John R. Paxton, Australian Museum Sydney for assistance in determination of the specimen and in the provision of literature not available in Tasmania.

Genus *DIRETMUS* Johnson, 1863

Diretmus Johnson, 1863, *Proc. zool. Soc. Lond.*, p.403. Type-species, *Diretmus argenteus* Johnson.
Discus Campbell, 1879, *Trans. N.Z. Inst.*, 2, p.297. Type-species, *Discus aureus* Campbell. Not *Discus* Fitzinger, 1833, Lesson, 1837.
Gyrinomene Vaillant, 1888, EXPED. 'TRAVAILLEUR' ET 'TALISMAN', POISS., pp. 18, 355. Type-species *Gyrinomene nummularis* Vaillant *nom. nud.* Also *Gyrinonemus auct.*
Campbellina Fowler, 1958, *Not. Nat.*, 310, p.15 (new name to replace *Campbellina*, preocc. in Mollusca).

Diretmus argenteus Johnson, 1863

Diretmus argenteus Johnson, *Proc. zool. Soc. Lond.*, p.403, pl.36, fig.1. Type locality: Madeira.
Diretmus argenteus: Günther, 1887, REPT CHALLENGER, ZOOL., 22(57), p.45: McCulloch, 1909, *Rec. Aust. Mus.*, 7(4), p.320: Woods & Sonoda, 1973, *Mem. Sears Found. Mar. Res.*, 1(6), p.20 (references and synonymy).

Tasmanian specimen

A juvenile example *Ls* 21.0 *Lt* 25.0 + (caudal imperfect) was found in the gut of a deep-sea trevalla, *Hyperoglyphe antarctica* (Carmichael, 1818) between 1 and 17 December 1977, taken in 460-550 m, by Mr John Head 27 km east-south-east of Tasman Island; Q.V.M. Reg. No. 1978/5/1.

Meristic characters

D.27 (species range (Woods & Sonoda 1973) 27, 28, rarely 26 or 29). A. 22 (21, 22, rarely 20 or 23). V.I, 6. C. *ca* 14 (fin damaged). Neither scales nor abdominal scutes are obvious, though there is some suggestion the latter may number about 11 + 11.

Dimensions as *TLs*

In this paragraph comparative ranges reported by Woods & Sonoda for 4 small specimens 48-92 mm and for 4 large specimens 212-262.5 are given in parentheses; their values as percentages (with one decimal figure), here rendered as millesimals. Greatest depth 776 (570-626, 457-460). Caudal peduncle, least depth 95.2 (92.6-117, 99.0-106), length 152 (125-163, 127-141). Head 433 (365-404, 352-378). Snout 85.7 (66.4-96, 6.95-90.4). Eye 195 (175-194, 158-195). Interorbital 66.7 (56.5-83.4, 47.2-5.95). Length of upper jaw 319 (250-294, 222-251). Length of pectoral 381 (337-385, 262-328). Length of ventral 238 (318-41.4, 290-340). The Tasmanian specimen is seen to lie outside the published ranges in three instances — whether these differences (all of greater magnitude) reflect possible influence of geographical or age factors or are attributable to mere individual variability remains unclear. However, the progressive decrease of depth with age in the three specifications above is expectable; Smith (1970, p.150) noting depth in length 1½ in juveniles to 2 in adults.

Other dimensions. Length between parallels to origin, termination of dorsal 400, 862, of anal 924, 952; oblique lengths of fin bases 490, 381. Length to pectoral, front of base 419, insertion of most anterior (uppermost) ray 433. Length to ventral 438. Length to insertion of outer rays of caudal 981, of middle rays 1 014. Depth at front of eye 286, at back of eye 600, at opercular border 714, at origin of ventral 714, midway between the last two points 776 (maximum), at vent 524. Greatest width of maxilla normal to long axis 148, obliquely 157.

Proportions

For the 4 proportions for which ranges are given in the Handbook (Munro 1958a) the values are: depth 1.29 (1.4-2.2), head 2.31 (2.5-2.9) in standard length; snout 5.51 (3.7), eye 2.22 (1.5-2.7) in head. From these data the snout would appear noticeably shorter in our fish than normal. However, the figure for head in snout as calculated from the means of the ranges for these two dimensions as given by Woods & Sonoda stands midway between the present and the Handbook values, being for the smaller examples 4.74, for the larger 4.57.

General observations

Both the currently accepted species, *D. argenteus* and *D. pauciradiatus* Woods, 1973 — the question of a separate genus for the latter has been mooted by Post & Hecht (1972), who, on the basis of otolith studies, further suggest this species may include two taxa — are decidedly variable in morphometric characters, the latter undergoing a series of changes in shape by allometric growth during ontogenesis (Post 1976), while *D. argenteus* is said to keep the disc shape of the juvenile. At the same time the constancy of shape thus implied for the present species would appear to be subject to some qualification. Our specimen — which at *Ls* 21 is less than half the length of the smallest example examined by Post & Sonoda, about one-fourth the nominal length of 3½ inches (90 mm) given by the Handbook, and about one-seventh the length attained by the species (itself about 0.4 that reached by *D. pauciradiatus*) — exhibits some distinct variations in outline when compared with Johnson's figure reproduced in the Handbook (Munro 1958a, fig. 543). The dorsal profile, depicted as overall a more or less

symmetrical moderately convex curve, here slopes up from eye to highest point near dorsal origin in two subequal approximately linear segments, the anterior at a much more acute angle; under the base of the dorsal the outline is again virtually linear. Little difference is apparent in the anterior half or more of the ventral profile but along the base of the anal the outline, figured as rather strongly convex, is close to straight and at the same time rises decidedly more steeply, resulting in a noticeable decrease in the longitudinal extension of the fin relative to its total oblique length, the former being only one-fifth of the latter.

Mouth cleft highly oblique. Maxilla with strong striae radiating up and back from point near middle of inferior border; reaching to below 0.9 (Handbook middle) of eye. Whole operculum striated, ridges tending to be stronger in upper half. Some spines along lower preopercular margin and bordering interoperculum. In front of dorsal two median protuberances, posterior as far from fin as from anterior, a distance equal to that occupied by five dorsal rays. No dorsal rays preserved, but their number and location clearly indicated by rounded pterygiophores together forming a continuous low crenulate ridge decreasing evenly in altitude backward. Only a few anal rays present, slender, simple, length about equal to diameter of pupil; pterygiophores clearly visible in a more or less pellucid palisade. Caudal damaged and terminally imperfect, rays as far as intact unbranched, some stout. Pectoral rays slender unbranched, 3rd longest little more than 1st and 2nd; fin base virtually horizontal. Ventral when adpressed fitting along a short backwardly and upwardly oblique straight segment of profile terminated behind by front of anal a trifle in advance of tip of ventral.

Coloration

The Handbook specification is 'uniform brownish. Fins grey. Inside of mouth black'. Our specimen though clearly at a quite early stage of overall pigmentation yet presents one large very striking marking, which, however, is probably not superficial (see below).

Ground color of trunk and tail uniform pale yellowish. A small brownish pennon, widest and darkest anteriorly, extending from behind head along dorsal part of body, close to profile, to level of first one-third of dorsal base; a very slender blackish line bordering dorsal base, surmounted by the whitish or pearly ridge of pterygiophores; below this and extending forward to top of head a longitudinal line of some thirty small brownish chromatophores, anterior half an eye diameter from, posterior virtually on, dorsal profile, continuous behind with a patch covering more than half caudal peduncle; from end of anal base a double series of about a score obliquely forward and downward for about an eye diameter. The only conspicuous large-scale marking on the trunk a sharply demarcated curved bar of uniform dark bluish, approaching blackish, extending from just above pectoral base to barely short of ventral profile immediately in advance of anal origin, widening downward to an eye diameter, ending in a straight line parallel to profile. Head in part darker than body; dorsum variably brownish; maxilla, operculum, preoperculum silvery or whitish; a subtriangular very dark brown spot above and behind eye near border of head at 2 o'clock (left side viewed); ventral surface partly silvery partly dusky, a median dark spot between ends of maxillae; an extension across head towards eye and mouth of the dark curved bar on the trunk, which appears to underlie the operculum and which may well represent the alimentary canal visible through the integument. Anal, caudal rays off-white, pectoral and ventral silvery white.

Distribution

The example noted by McCulloch (1909) was taken in deep water south-east of Cape Howe (near border of Victoria and New South Wales, leading some overseas writers to cite latter State); this is the only locality recorded in the Handbook. The species has been obtained in New Zealand, Campbell's material (the description of which led him

to propose his genus *Discus*) coming from Hokitika beach: the distribution indeed is world wide in tropical and temperate waters but is mainly eurytropic.

Family SYNGNATHIDAE

Genus *SOLEGNATHUS* Swainson, 1839

Solegnathus Swainson, 1839, NAT. HIST. CLASSIF. FISH. AMPHIB. REPT, 2, p.333. Type-species, *Solegnathus hardwickii* Gray.
Solegnathus: McCulloch, 1929, *Aust. Mus. Mem.*, 5(1), p.94 (references and synonymy).

Solegnathus fasciatus Günther, 1880

Solegnathus fasciatus Günther, 1880, REPT VOY CHALLENGER, ZOOL., 1(6), p.30, pl.14, fig.B. Type locality: Off Twofold Bay, New South Wales.

Recent material

A series of 7 specimens, (a) ♀ *Lt* 142, (b) ♀ 264, (c) ♂ 305, (d) ♀ 319, (e) ♀ 344, (f) ♂ 355, (g) ♂ 361, collected by Mr Shane Downe on 10 June 1978 in 110 m off St Helens Point, east coast (Q.V.M. Reg. No. 1978/5/83) provides some additional information on this species.

Meristic characters

D. 36 (2 individuals), 37 (3), 38 (2). P. 24 (3), 25, 26 (2), 27. Annuli 24, 25 (3), 26 (3) + 56 (2), 57 (3), 58, 60. Subdorsal annuli 0.9 of 1st; 0.0, 0.4, 0.5, 0.6 (2), 0.7 of 2nd (counting fractions cephalad) + 0.8, 0.9 (2) of 11th; 0.4, 0.5 (3) of 12th. Brood pouch: (c) incipient or regressed, traceable through 17 caudal annuli, (f) in 2 rows on 17 annuli, (a) in 2 rows on 19 annuli. Prehensile caudal annuli 28, 29, 30 (4), 31.

Dimensions

Table 1 records for each of 25 dimensions, expressed as millesimals of total length, range, mean with standard error, coefficient of variation with standard error. The inclusion of the coefficient of variation provides a useful indication of the taxonomic value of the variate. For a tolerably homogeneous sample such as the present it may broadly be taken that values of V of > 5, of > 5 < 10, of > 10 suggest the variate is likely to be of considerable, of fair, of little value, respectively, as a systematic criterion; however, this assessment is not necessarily valid in the case of a dimension exhibiting allometric or other differential growth.

Proportions, conspectus values

Eye in snout, range 2.8-4.6, mean 3.72±0.606, coefficient of variation 43.1 ± 19.7. Snout in head 1.7-2.0, 1.79±0.0319, 4.7±1.3. Head in trunk 2.0-2.1, 2.04 ± 0.0185, 2.4±0.6. Trunk in tail 1.1-1.2, 1.16±0.0504, 4.5±1.2.

In the conspectus of Part X (1961) the available published values for these 4 ratios were collated, as ranges, for all Tasmanian syngnathids. There here follow for each ratio in this species conspectus range, range of 3 individuals noted in Part XI (1963), range of present 7 examples. Eye in snout 4.0-5.0, 4.0-5.6*, 2.8*-4.6, snout in head 1.6-1.7, 1.6-1.7, 1.7-2.0*, head in trunk 2.0, 2.0-2.4*, 2.0-2.1, trunk in tail 1.1, 1.0*-1.1, 1.1-1.2*. The 1961 synoptic range is thus extended for 6 values (asterisked), of which 3 are provided by the present material.

Meristic ranges specified in the conspectus are here transgressed by trunk annuli 24-26 (*cf.* 25-28) and caudal annuli 55-60 (*cf.* 51-56). Pectoral rays are not noted in the conspectus: no counts are given by Munro (1958c) or by Scott *et al.* (1974), while this species is not dealt with in the review of the South Australian lophiobranchiates

TABLE 1

Solegnathus fasciatus Günther, 1880. Dimensions of 7 specimens from off St Helens Point, east coast, Tasmania (Mr Shane Downe). First line, total length, mm, all other lines millesimals of total length.

Dimension	Range	$\bar{x}$	V
Total length, mm	142-361	298.6 ±28.994	25.7 ± 9.6
Length to pectoral origin	190-203	196.3 ± 1.784	2.4 ± 0.6
Length to dorsal origin	552-590	571.7 ± 5.148	2.4 ± 0.6
Length to dorsal termination	664-702	682.1 ± 5.202	2.0 ± 0.5
Length to vent	541-581	559.1 ± 5.528	2.6 ± 0.7
Head	178-189	182.1 ± 1.557	2.3 ± 0.6
Snout	97-108	102.7 ± 1.503	3.9 ± 1.0
Eye	23- 35	26.2 ± 1.655	16.7 ± 4.6
Interorbital	7- 12	10.4 ± 0.612	15.6 ± 4.3
Depth at front of eye	12- 28	19.6 ± 2.104	28.4 ± 8.2
Depth at opercular border	31- 36	33.2 ± 0.611	4.9 ± 1.3
Depth at front of vent	33- 64	45.6 ± 3.985	13.1 ± 6.5
Depth at back of vent	30- 34	31.9 ± 0.506	4.2 ± 1.1
Maximum depth	46- 82	57.2 ± 4.485	21.5 ± 6.0
Dorsal base	96-126	110.4 ± 3.673	8.8 ± 2.4
Length of pectoral, total	22- 41	28.1 ± 2.502	23.5 ± 6.6
Length of longest pectoral ray	19- 28	22.7 ± 1.388	16.2 ± 4.4
Pectoral base, oblique	26- 35	29.9 ± 1.074	9.5 ± 2.6
Tail	419-459	440.9 ± 5.528	3.3 ± 0.9
Trunk	363-399	376.9 ± 5.422	3.8 ± 1.0
Width at front of eye	14- 20	16.1 ± 0.982	16.2 ± 4.4
Width at opercular border	20- 28	22.1 ± 1.092	13.1 ± 3.6
Width at front of vent	26- 32	29.6 ± 0.868	8.6 ± 2.3
Width at back of vent	26- 33	29.8 ± 1.062	9.4 ± 2.5
Maximum width of head	24- 32	27.8 ± 0.678	8.9 ± 2.4
Maximum width of body	32- 44	37.8 ± 1.646	11.5 ± 3.1

by Waite & Hale (1921). Pooled counts for the present material and the 1963 specimens are 24 (3), 25 (3), 26 (3), 27.

Size classes

Specimen (a), *Lt* 142, is evidently the sole representative of one age group. Specimens (c) - (g), *Lt* 305-361 would appear very probably to be coeval with each other. The status of (b), *Lt* 264, is uncertain. If it is included with the 5 other specimens, the pooled V of 11.6 is somewhat high for a homogeneous group, and exclusion of the male leaves V for the resultant sample virtually unchanged at 11.7 : if it is tested, in accordance with the procedure recommended by Simpson & Roe (1939) for the comparison of a single individual with a small series, against the standard deviation (df = n-1) of (c) - (g), t comes out at 3.031, somewhat below the 3.162 required for P 0.05. On the balance of probabilities (including circumstances of collection), (b) is perhaps best tentatively included with the larger individuals, a course that would receive some support from the fact it is a female.

Sex dimorphism

Differences in proportion between the sexes have been reported or suggested for several features; some addition is here made to the information currently available. There are some complicative indications that some ratios are size-determined.
(i) Depth of trunk. In the 1963 ♂ (*Lt* 343) maximum depth of trunk in length of trunk is 6.0, in the ♀♀ (*Lt* 353.5, 387.5) 5.0, 4.3 or in *Lt* ♂ 15.2, ♀♀ 12.6, 10.8. In the

present sample the values are, in trunk ♂♂ 6.3, 10.2, 5.2, ♀♀ 9.0, 7.1, 6.2, 4.5, or in *Lt* 16.9, 28.0, 13.1 and 24.5, 18.9, 16.7 11.5. The mean values, depth in trunk length ♂♂ 7.1, ♀♀ 6.7, depth in *Lt* 19.3, 17.9, are thus in agreement with the suggestion afforded by the (very small) 1963 sample that the trunk in males is relatively shallower: it is to be noted, however, first that there is very considerable variation, leading to intersection of the two sex sets, secondly that among females at least the values of both ratios decrease (tolerably regularly) with increase in size of fish. A shallower trunk in males has been noted by Waite (1894, p.22) in specimens identified by him as *S. hardwickii* Gray, 1830 (type locality China : Australian records are now generally discounted (McCulloch 1929, Munro 1958c), Waite's material being referred by Whitley (1927) to *S. dunckeri* Whitley 1927).

(ii) Length of head. In the 1963 material ♂ head in trunk is 2.35, ♀♀ 2.20, 2.45, or, in *Lt* 6.02 and 5.57, 5.34. In the present material the ♂ values are, in trunk 1.96, 2.05, 2.04, in *Lt* 5.30, 5.64, 5.64 and the ♀ in trunk 2.00, 2.07, 2.03, 2.13, in *Lt* 5.46, 5.51, 5.50, 5.38. Thus in the present sample mean male head (2.01 *v.* 2.06) is slightly longer relative to trunk but is slightly shorter (5.53 *v.* 5.46) relative to total length, the latter result being compatible with the figures for both the in-trunk and in-*Lt* ratios of the 1963 specimens, while the former is in conflict with both the 1963 situations.

(iii) Length of snout. While in Part XI it is correctly noted that the snout of the male is shorter relative to *Lt* than those of the females (9.80 *v.* 9.06, 9.23), examination of the dimensions there recorded shows this difference does not hold when snout in head is calculated, the male value 1.63 being equal to the value of one female, (a), though less than that of (b), 1.73. In the present material the snout in *Lt* is ♂♂ 9.53, 9.86, 10.1 (mean 9.90), ♀♀ 10.07, 9.36, 9.38, 9.83 (mean 9.06), in head ♂♂ 1.80, 1.75, 1.83 (mean 1.79), ♀♀ 1.84, 1.70, 1.71. 1.83 (mean 1.77) — there is thus no significant difference here between the sexes in respect of this feature, though the mean values of the ratios are marginally larger in the male.

(iv) Width of tail immediately behind vent. It is noted of the 1963 material 'Though the male (c) is 10.5 mm less in *Lt* than the smaller female (a), the width of the ventral surface of the tail immediately behind the vent is more than one-fourth as great again.' Marked sexual dimorphism in relative size and in form of early tail scutes has been reported by Waite (1894) in the Australian pipefish identified by him as *S. hardwickii*, and Whitley states of the same form, his *S. dunckeri*, the sides of the tail rings are 'much expanded.' No marked difference in form is found here, though the ventral surface of the tail in about a score of annuli back from the vent appears to be somewhat flatter and smoother in males. Total width just behind vent, as *TLt* here is ♂♂ 29.5, 31.0, 31.9, ♀♀ 25.4, 26.2, 31.7, 32.6, there thus being in both sexes some relative increase with increase in size of fish.

(v) Length of body. A 'relatively longer body' in the female has been reported by Whitley (1945, p.223) for *S. spinosissimus* (Günther, 1870), a species first described from this State. No significant difference is apparent in our material of the present species; with 'body' interpreted as trunk the male, female *TLs* means being 384.8, 383.3, or interpreted as head plus trunk 556.8, 566.2.

Relative growth

The frequently large ranges in values found for relative lengths of head, trunk, tail, iterns customarily reported in specific diagnoses of syngnathids, suggests the probability that these are not solely attributable to individual variation but involve as a component differential growth of the regions concerned. Data for the present material afford evidence of a positive correlation of relative length of trunk and a negative correlation of length of tail with total length, length of head remaining significantly constant. With the regions as millesimals of total length the

results are: trunk r + 0.699 (z 0.866), t 2.187, tail r − 0.723 (z 0.914), t 2.342, head r + 0.172 (z 0.174).

Length of head, length to vent, total length.

Notwithstanding the conclusions noted in the preceding paragraph, the antero-posterior extensions of the three primary regions of the fish, head (h), trunk (b) and tail (t) are such overall that the three points with coordinates (log h, log 1), (log $(h+b)$, log 2), (log $(h+b+t)$, log 3) are significantly collinear. Each of the subjoined statements sets out for one of the 7 specimens (arranged in order of ascending magnitude of total length) the equation of the regression of length, mm, L on natural number, N : t, with indication of significance : values of the variate as predicted by the equation (measured values in parentheses).

Log L = 1.5496 log N + 1.4179 : 54.914* : 26.2(26), 76.6(76), 143.6(142).
Log L = 1.5606 log N + 1.6849 : 34.159* : 48.4(47.9), 142.8(147), 268.9(264).
Log L = 1.5235 log N + 1.7629 : 34.493* : 57.9(57.5), 166.6(170), 308.9(305).
Log L = 1.5572 log N + 1.7670 : 43.884* : 58.5(58), 172.1(170), 323.6(319).
Log L = 1.5430 log N + 1.8144 : 19.189* : 65.2(64), 190.1(200), 355.3(344).
Log L = 1.5775 log N + 1.8108 : 65.272* : 63.4(63), 189.1(192), 358.4(355).
Log L = 1.5733 log N + 1.8214 : 18.779* : 66.3(65), 197.3(208), 373.3(361).

It will be seen the fits are satisfactory. Percentage deviations of the 21 predicted lengths from measured lengths range from 0.6 to 5.2 with mean 1.91±0.273, while the means for individual specimens range from 1.0 to 3.5. It should be noted the sum of the squares of the deviations from the mean in the equation is that of the logarithmic values, while the deviations recorded above are back-calculated to the arithmetic deviations, given here in preference to the formally more appropriate logarithmic deviations as being likely to be of more immediate interest to the practising systematist.

No correlation of the slope of the graph with the length of the specimen is evident. On the contrary the value of the slope is sufficiently stable to render evident on inspection an expectable increase in magnitude of the intercept with increase in size of fish: r + 0.990 (z 2.628), t 6.388***.

Examination of the data for 3 specimens dredged by Mr B.C. Mollison in 11-18 m in D'Entrecasteaux Channel, off Middleton, and noted in Part XI (1963, p.17, fig.6) reveals the same pattern in this material. Specifications as before:

Log L = 1.6455 log N + 1.7629 : 20.836* : 57.9(57), 181.2(191), 353.2(343).
Log L = 1.5750 log N + 1.8110 : 19.391* : 64.9(63.5), 214.3(228.5), 398.4(382.5).
Log L = 1.5294 log N + 1.8706 : 15.096* : 74.2(72.5), 214.3(228.5), 398.4(382.5).

For this material the percentage deviations of predicted from measured lengths range from 1.6 to 6.2, with mean 3.65±0.523. The correlation of intercept and total length is r + 0.971 (z 2.127), which though a large value is below that (0.997) required for significance at P 0.05. For these 3 individuals the slope decreases with increase in length of fish, but the correlation r − 0.926 (z 1.629) is not formally singificant.

Coloration

The only notices of coloration in the original account of the species (Günther 1880, p.41) are 'the back of the trunk ornamented with seven narrow blackish cross-bars', 'the preanal region is blackish'. In a postscript to a general account of *Solegnathus* Waite (1894, p.227) affords what may well be regarded as a classic instance of the rationale of Museum systematics 'I have purposely avoided giving particulars of colouration, but have pointed out such characters as will enable anyone to determine the three species either from dry or spirit specimens'. Indeed, not only are accounts in the literature meagre but they exhibit some confusion, particularly

in regard to the coloration of the immediately preanal segments. The following notes provide a summary of fairly detailed observations on Mr Downe's seven specimens made shortly after they were received from him.
General color.- Trunk: delicate pale pink with a hint of underlying silver; a little lighter on dorsal surface. Tail: lateral and dorsal surfaces much like those of trunk; ventral surface of first 10-12 annuli very pale almost white, sharply demarcated from next 15-20, which are pinkish or deep yellow with pinkish tinge; prehensile pads white. Head: anterior half or so of snout in some specimens almost colorless on side, in others yellow with very narrow pinkish line along each ventrolateral border; hind half yellowish, pinkish or pinkish yellow; operculum mainly purplish, in some specimens the striae yellowish, each with some deeper dots tending to form about six arcs; rest of head very much like trunk, sometimes rather more yellowish on chin and throat.

Chief markings.- Trunk: (a) lateral surface, on upper half or more a well-defined bar of bright slightly greenish yellow at junction of scutes, the upper extremity pointed, bars ending evenly along a line running forward from upper part of vent; (b) dorsal surface, on each annulus a reddish brown lozenge, its external points meeting the lateral bars, interspace about two-thirds anteroposterior axis of marking, also, very well developed in 1 specimen, fairly well in 2, poorly in rest, a series of 6-7 medium or dark green more or less hourglass-shaped markings, in one specimen occurring on rings 2, 7-8, 13-14, 16-17, 21-22, 24-25; (c) ventral surface, along midventral ridge a rich yellow or orange line, either continuous of about even width throughout or with a more or less rounded expansion on each segment; on last trunk annuli a very conspicuous subrectangular patch of bright red (in one individual some very dark green approaching black in lower part), extending up on to lateral surface to reach bottom of yellow bars there. Tail: (a) lateral surface, a continuation or partial continuation of the series of yellow bars of the trunk, exhibiting considerable variation, occasionally even petering out posteriorly; (b) dorsal surface, some traces of a continuation of the hourglass-like trunk markings, here tending to become pinkish; (c) ventral surface, without pronounced markings.

Dorsal fin pinkish or pale orange. Pectoral with a very narrow proximal arc of deep pink, thence to about middle of length yellowish green, thereafter pale pink.

Genus *STIGMATOPHORA* Kaup, 1853

Stigmatopora Kaup, 1853, *Arch. Naturges.*, 19(1), p.233. Type-species, *Syngnathus argus* Richardson.
Stigmatophora Kaup, CAT. LPHOBR. FISH. BRIT. MUS., p.52; *emend.*

Stigmatophora argus (Richardson, 1840)

Syngnathus argus Richardson, 1840, *Proc. zool. Soc. Lond.*, 8, p.29. Type locality : not specified, = Tasmania, *fide* McCulloch (1929).
Stigmatophora argus : McCulloch, 1929, *Aust. Mus. Mem.*, 5(1), 1929, p.93 (references and synonymy): Waite & Hale, 1921, *Rec. S. Aust. Mus.*, 1(4), p.308, fig.48.

Recent material
Three examples (a) ♂ *Lt* 196, (b) ♀ 225, (c) ♀ 255, collected by Mr Shane Downe in a sardine net off St Helens Point, east coast, on 10 July 1978 (Q.V.M. Reg. No. 1978/5/89), make possible some extension of current knowledge of the species.

Meristic characters
D. 61, 51, 61. P. 17, 16, 16. Annuli 19 + 85, 20 + 76, 20 + 80. Subdorsal annuli 0.9, 0.7, 0.3 of 11th trunk (counting fractions cephalad) to 0.4, 0.9, 0.6 of 12th caudal. Brood pouch, (a), 0.6 of last trunk annulus to 0.9 of 19th caudal.

Dimensions as *TLs*.

Length to origin of pectoral 16.8, 182, 173, origin of dorsal 296, 317, 299, termination of dorsal 514, 541, 529. Length to vent 385, 413, 422. Head 162, 170, 162, snout 112, 123, 113, eye 16.8, 13.8, 16.1, orbit 19.9, 17.8, 21.6, interorbital 6.1, 5.8, 7.5. Depth (in parentheses width) at front of eye 12.8, 15.1, 13.3 (12.8, 13.8, 9.4), operculum 15.3, 17.8, 15.7 (17.9, 15.6, 20.0), vent 14.8, 17.8, 15.7 (18.9, 22.2, 23.4); maximum 16.8, 22.7, 20.8 (20.4, 28.4, 27.1), some signs of dorsoventral collapse after preservation.

Conspectus values

Meristic characters above are in agreement with the synoptic counts of the conspectus in Part X (1961, p.61) as revised for this species in Part XI (1963, p.19); however, in the case of the subdorsal annuli on the trunk the present specifications, while covered by the datum 0.2 of the 11th annulus (counting fraction cephalad) of the 1963 individual, transgress the original (1961) specification of 7-10 annuli.

For the 4 morphometric entries in the conspectus the values here are: eye in snout 6.6, 8.9, 7.0 (*cf.* 6.0-9.3, 1963 5.6), snout in head 1.5, 1.5, 1.4 (1.4-1.6), head in trunk 1.37, 1.43, 1.61 (1.3-1.7), trunk in tail 2.76, 2.41, 2.27 (1.7-2.8), i.e., all are covered by the synoptic ranges, with one value, trunk in tail, standing on the conspectus maximum.

Comparison with published data

In their review of the lophobranchiate fishes of South Australia Waite & Hale (1921) have provided what may well be regarded as the definitive account of this species. The following comparisons with their specifications with data from the present material reveal some variations and afford some quantification of statements of a general nature. Snouth with "a low median crest which terminates in advance of the eyes" : in (a) 0.7 eye diameter before eye, a little closer to nostril than latter is to eye; (b), (c) 0.8, 1.1 eye diameter. "The supraorbital ridges commence on the posterior third of the snout, but do not extend to behind the eyes" : originate at 0.72, 0.72, 0.79 of snout, cease at about 0.9 eye, continuous with lateral occipital ridge, which extends back to level of first third of operculum. "A lateral ridge from the angle of the mouth to the lower part of the front edge of the eye" : (a) just reaches orbit at 9 o'clock (left side viewed) after bending upward slightly, (b) at level of posterior nostril dips down slightly, becomes continuous with orbital ridge at first third of eye, (c) reaches orbit at 9 o'clock. "Low ridges define the lower margins of the snout, one on each side of a median ventral ridge, which bifurcates below the front margins of the eyes" : (a) bifurcates at front of eye, extends to 1.1 eye, (b) at 0.4 eye, to 1.1 eye, its width here a little greater than distance from profile, (c) at 0.5 eye in advance of eye, to 1.2 eye; in (a), (b) lateral ridges just meet ends of divided median slowly curving in to it from level of front of eye, in (c) end a little externad of ends of divided median. "A feeble opercular ridge in young examples" : (a) on left 0.5 length of operculum, on right full length though low in hind half, (b) left 0.95, right 0.45, (c) strong, full length on both sides. "Upper and lower ridges continuous, much more distinct on the tail" : ridge starts (a) barely behind level of operculum, (b), (c) at four-fifths of distance from end of operculum to ridge of pectoral base. "The lateral ridge extends on to about the sixth caudal scute or terminates in the skinny folds of the brood pouch" : (a) continues on left to 10th, on right to 9th scute followed by a short separate segment, (b) left 20th, right 23rd, (c) on left ceases on last body scute, on right to 1st caudal — for continuation of the median trunk ridge beyond the 6th caudal scute see also Part XI (1963, p.20). Midventral trunk ridge starts (a) below first third of pectoral, (b) slightly behind level of end of operculum, (c) below first fourth of pectoral; in all continuous to vent. Median ventral caudal ridge in (a) fully continuous for first third of tail, (b) barely indicated through 11 segments, (c) continuous from end of pouch about to middle of tail.

Coloration

(i) Females. General dorsal and lateral surfaces olivaceous, lower trunk pale yellowish green; tail with first third greyish with some greenish tinge, tending to become bronzy, markedly so in last half. From shortly behind head upper lateral ridges becoming increasingly reddish brown posteriorly, strongly so in last two-thirds of tail. Operculum silvery with very minute black dots on upper half. On dorsum of trunk and of first 25 annuli of tail small paired dark dots between annuli in dorso-lateral ridges. In (a) basal half of pectoral golden.

(ii) Male. General color olivaceous above and on sides; ventral surface of trunk and tail (apart from pouch) greyish; first half dozen trunk annuli with midventral stripe of pale yellowish green including numerous melanophores; some scattered melanophores also on rest of trunk. First 30 caudal annuli with dorsal ridges light grey with ever increasing series of dark dots, behind these annuli ridges continuous dark lines. Pectoral silvery with minute dark punctulations. The coloration of the pouch is striking and handsome. Ground color pale silvery grey with some delicate gradation; a pronounced fairly wide median stripe of purplish divaricating anteriorly to embrace the light yellow anal papilla, again divaricating some 45 mm further back; a narrow purplish line on either side just inside lateral border of tail; between these and mid-ventral stripe two somewhat irregular purplish lines, that on right about two-thirds length of median stripe, that on left about half; narrow lateral strips outside lateral lines dark green.

Genus *SYNGNATHUS* Linné, 1758

Syngnathus Linné, 1758, SYST. NAT., ed. 10, p.336. *Ex* Artedi. Type species, *Syngnathus acus* Linné.

Syngnathus phillipi Lucas, 1891

Syngnathus phillipi Lucas, 1891, *Proc. R. Soc. Vict.* (n.s.), 3, pp. 8,12. Type locality: Port Phillip Heads, Victoria.
Corythoichthys phillipi: McCulloch, 1911, ZOOL. RES. ENDEAVOUR, 1, p.26, fig.10, and 1929, *Aust. Mus. Mem.* 5(1), p.85.
Parasyngnathus phillipi: Whitley & Allan, 1958, THE SEAHORSE AND ITS RELATIVES, p.8: Whitley, 1969, *Proc. Linn. Soc. N.S.W.*, 89(1), p.36.

Remarks

This species has been the subject of somewhat detailed investigation in Part XXIII (1977). As there pointed out the dichotomy found by Herald (1953) between intertidal and deepwater forms in the Marshall and Marshall Islands with division of the two habitats at 3-5 m does not hold good for *Syngnathus phillipi*, which on the one hand is abundant in intertidal rock pools and along estuary shores on our northern coast and (Scott *et al.* 1974) in shallow weedy areas in the South Australian Gulfs, and on the other hand has been dredged (Scott 1963) in 16-24 m, with a possibility that the material collected in Tasmania by the *Endeavour* was obtained at still greater depths (McCulloch 1911). It is of some interest to note the finding of a specimen, *Ls* 116.0, *Lt* 117.1, in the stomach of a flathead (Platycephalidae; species undetermined) taken in Schouten Passage, east coast, in 4 m in April 1978 by Mr John Head (Q.V.M. Reg. No. 1978/5/66). The fish was quite intact showing little if any indication of having undergone digestion.

Proportions

In respect of the proportions recorded in the conspectus in Part X (1961, p.59), all of which were single values not ranges, all those of the present specimen are in disagreement; however, they fall within the rather wide ranges given in Part XXXIII (1977, p.130). Eye in snout 3.65 (2.63-3.68), snout in head 1.97 (1.7-2.58), head in

trunk 1.92 (1.69-2.42), trunk in tail 2.72 (2.1-2.9). Meristic figures also fall within the 1977 ranges. Annuli 18 + 44 (18-20 + 40-44), subdorsal annuli 0 + 1-6 (0-1.4 + 5.0-6.1), brood pouch annuli 0.9-16.8 (0.1 + 15-18), dorsal rays 25 (20-28).

Body regions

The lengths of head, head plus trunk, head + trunk + tail are collinear (t = 79.672**) in a loglog plot on 1,2,4 (contrast 1,2,3 for *Solegnathus fasciatus*):

Log L = 1.5111 log N + 1.1617; predicted (measured) lengths, mm, 14.5 (14.4), 41.4 (42.0), 117.8 (117.1).

The finding of this relation for this specimen has prompted the making of a comparable calculation for the material examined in Part XXIII: the formulation is valid for this also: for the 2 examples from Dianas Basin, east coast, t = 46.228*: 21.348* (smaller specimen first): with as primary data the geometric means of the relevant lengths in the sample of 24 from Kelso and Low Head, Tamar estuary, north coast and with the equation treated as having d.f.1, t = 26.278* (measured lengths back-calculated from geometric means)

Log L = 1.5241 log N + 1.1026; 12.7 (12.5), 36.4 (37.4), 104.8 (103.4).
Log L = 1.5452 log N + 1.1661; 14.7 (14.8), 42.0 (42.8), 126.5 (125.0).
Log L = 1.5068 log N + 1.1113; 12.9 (12.6), 36.7 (38.4), 104.3 (102.0).

Family SPHYRAENIDAE

Genus *AUSTROLUZZA* Whitley, 1947

Austroluzza Whitley, 1947, *Aust. Zool.*, 11(2), p.136. Type-species, *Sphyraena novae Hollandiae* Günther, 1860.
Sphyraena: McCulloch, 1929, *Aust. Mus. Mem.*, 5(1), p.121, *partim*. Not *Sphyraena* Bloch & Scheider, 1801.

Austroluzza novaehollandiae (Günther, 1860)

Sphyraena novae Hollandiae Günther, 1860, CAT. FISH. BRIT. MUS., 2, p.335. Type locality: Hobson's Bay, Victoria.

Food of seal

A Tasmanian Fur Seal, *Arctocephalus doriferus* Jones, 1925, about 2 m in length stranded at Kelso, Tamar estuary, north coast, on 6 November 1978 was found to have in its stomach a complete example of this species, *Ls* 417 *Lt* 472, length to end of middle caudal rays 447. The fish had been swallowed whole and was quite without tooth marks. Some dissolution was apparent in the head and some skin was missing as far back as the first dorsal, behind which the body was firm and lacked any sign of damage.

Proportions

Four proportions are noted in the Handbook (Munro 1958d); values for this specimen fall outside these limits in three cases. Depth in total length 11.51 (Munro 9-11), head in total length 4.03 (4-4.5). Eye in head 8.67 (6-7). Eye in snout, tip of lower jaw 4.67. tip of upper jaw 4.30 ('about 3').

Family SCOMBRIDAE

In their provisional classification of living teleosts Greenwood *et al.* (1966) combine in the wide group Scombridae six or eight groups recognized by most Australian authors as representing distinct families. The species here noted, the butterfly mackerel, *Gasteroschisma melampus* Richardson, 1845, was placed by McCulloch (1922) in Scombridae, later (1929) in Scomberomeridae, where it was accommodated also by Whitley (1962); however in the Handbook (Munro 1958e) it is referred to Gasteroschismatidae

(rendered Gasterochismidae by Greenwood *et al.* in their synonymy).

Genus *GASTEROCHISMA* Richardson, 1845

Gasterochisma Richardson, 1845, *Ann. Mag. Nat. Hist.*, 15, p.346. Type-species, *Gasterochisma melampus* Richardson.
Lepidothynnus Günther, 1889, ZOOL. VOY. CHALLENGER, 31(78), p.15. Type-species, *Lepidothynnus huttoni* Günther.

Gasterochisma melampus Richardson, 1845

Gasterochisma melampus Richardson, 1845, *Ann. Mag. Nat. Hist.*, 15, p.346. Type locality: Port Nicholson, New Zealand.
Lepidothynnus huttoni Günther, 1889, ZOOL. VOY. CHALLENGER, 31(78), p.15, pl.6, figs A, A'. Type locality : Lyttleton, New Zealand.

Tasmanian occurrence

In including this species in his first catalogue Johnston (1883, p.118) noted the recent capture of an example in the Derwent; the same individual is presumably that mentioned by Lord & Scott (1924, p.79) as being taken 'in Storm Bay, at the entrance to the Derwent'. There appear to be no other published primary records of the species in our waters, where it is evidently rare. On 14 November 1978 Mr Peter McQueeney found a specimen, *Ls* 372, dead or dying at the tide line at Falmouth, east coast, and by the good offices of Mr Tim McManus this was secured for the Queen Victoria Museum (Reg. No. 1978/5/107). No counts or measurements of local material being available the opportunity is here taken to record some basic data on the present fish. It may be remarked that while the species is recorded also from Queensland, New South Wales, Victoria, it has not hitherto been met with in South Australia; it is an oceanic form, occasionally coming ashore.

Meristic characters

D. XVI; I, 9; 8 finlets. A. II, 10; 8 finlets. P. 22. L. lat. 72. L. tr. 7 + 21. The Handbook states gill rakers are absent. While there are no elongate rodlike structures, the anterior arch bears 11 small spinulose mounds, placed about their own diameter, 2 mm, apart at the middle of the series, closer together at the ends.

Dimensions as *TLs*

Length to tip of upper caudal lobe 1231, tip of lower caudal lobe 1204, end of middle caudal rays 1054. Length to origin, termination of first dorsal 253, 556, of second dorsal 594, 719, of anal 632, 723. Length to vent (middle) 613. Length to origin of pectoral 250, of ventral 250. Total length of pectoral 151, of ventral 349. Outer caudal rays inserted well in advance of median rays, length to upper origin of fin 949, lower 962. Head 242. Snout 92.7. Eye, horizontal diameter 29.8, vertical 32.5. Interorbital 67.2. Depth (in parentheses width) at front of eye 153 (83), back of eye 188 (91), opercular border 263 (108), vent 245 (99); maximum 277 (118); caudal peduncle 37.6 (47).

Proportions

Greatest depth 3.61 (Handbook 3.9-4.1), head 4.13 (4-4.1) in standard length. Depth of caudal peduncle 6.43 in head. Eye, horizontal 8.11, vertical 7.44 (5.5-7.4, presumably horizontal) in head. Eye, horizontal 3.11, vertical 2.85 in snout, 2.25, 2.07 in interorbital. Pectoral 6.64 in standard length, 1.61 in head. Ventral 2.87 in standard length, 1.44 head. First dorsal base (to last spine) 3.29, second dorsal base (to last ray) 8.00, anal base (to last ray) 10.94 in standard length.

General observations

Ventral a very large black fan: this fin regularly of great size in the young —

in Richardson's figure about one-third total length, here 3.52 in total length — but assuming normal dimensions in the adult — in figure by Günther (1889, pl. 6, fig.A) of a 65½ inch (1.66 m) example of his synonymic *Lepidothynnus huttoni* fin contained about 10 times in total length, here 3.52 times. Fin wholly depressible into a deep smooth groove extending in present specimen from fin origin (accommodating part of its base) for 360 *TLs* units, slightly longer than fin, 349; on being subject to slight pressure in this region shortly after receipt the fish split neatly open along middle of whole groove. Spinous dorsal and anal also capable of being received into grooves. Dorsal fins known to be united basally in young widely separated in adult — in Günther's large fish interdorsal (from figure) about half first dorsal base or about 120 *TLs* units; in present specimen 0.13 dorsal base or 38 *TLs* units; in Richardson's figure the two dorsals very nearly united. Finlets subtriangular, but prolonged behind to form a pennon; most anterior bushy, not or barely separate from main fin; highest dorsal finlet 1.7 in eye (horizontal). Dorsal spines slender, flexible, some strongly recurved distally. Longest dorsal spine (6th=7th) 2.1, dorsal ray (4th) 3.1, anal ray (1st=2nd) 3.3, pectoral ray (1st=2nd) 1.9 in head. Maxilla to 0.5 eye, its maximum width 1.9 in eye (horizontal) or 1.2 its shortest distance from orbit. Lower lip projecting slightly; mouth cleft sharply turned down posteriorly. No keel on caudal peduncle.

Scales on whole of trunk and tail not extending on to fins; head with scales continuing from nape on to dorsum to level of middle of eye; a patch of scales on preoperculum but rest of head naked. Teeth in jaws all small, varying in bulk by a factor of about 10, mainly uniserial, exceptionally 2 side by side; 27, 29 in two sides of upper jaw, 20, 30 in lower jaw. General color bluish grey, lighter tending to whitish below line from pectoral base to vent. Head in general much like body, ivory in most of operculum. Dorsal dark grey, finlets off-white. Anal light grey, finlets greyish or off-white. Pectoral pale olivaceous. Ventral black. Caudal mainly pale olivaceous, darker approaching black across base and for some distance up outer rays.

As has been found to be the case in a number of fishes the lengths of the primary regions head, head + trunk, head + trunk + tail are specifiable as linear on three early natural numbers, here 1, 2, 3.

Log L = 1.2970 log N + 1.9578; t = 22.805*; predicted (measured) lengths, mm, 91 (90), 223 (228), 377 (372).

Family CARANGIDAE

Four species currently recognized as valid are known to occur in Tasmania, though twice this number of names appear in the lists of Johnston (1883, 1891), Lord (1923, 1927), Lord & Scott (1924); in the following sorting out of their synonymy these lists are denoted by J_1, J_2, L_1, L_2, L & S, respectively.

1. *Naucrates ductor* Linné, 1758. In all lists thus, in J_1 J_2 in Scombridae.

2. *Seriola grandis* Castelnau, 1872. J_1 thus, plus, with reservation, *Seriola Lalandii* Cuv. and Val. (= Cuvier, 1833), 'Doubtful. I have not seen any specimens', this species No. 365 in Macleay (1881b), not noticed in the Check-list (McCulloch 1929). J_2 both these species listed without comment. L_1, L_2, L & S. as here.

3. *Trachurus declivis* (Jenyns, 1841). J_1, J_2 *Trachurus trachurus* Cuv. and Val. (= *Scomber trachurus* Linné, 1758), i.e., identification of the Australian with a European species. L_1 *Trachurus declivis* Jenys [sic], plus (the synonymic) *Trachurus nouae-zelandiae* Rich. L_2, L & S same two species.

4. *Usacaranx nobilis* (Macleay, 1881a). J_1, J_2, L_1, L & S *Caranx georgianus* Cuv. and Val. (= Cuvier, 1883; second binomen with initial capital in J_1, J_2). L_2 *Longirostrum georgianum* Cuv. and Val. All local lists include a misidentification that continued to be accepted in the Check-list (McCulloch 1929, p.188), in which Macleay's species is treated as a synonym of Cuvier's. It is now established — as recognized in the Handbook (Munro 1960, p.126) — these are separate species,

Usacaranx nobilis (Macleay, 1881a), type locality Port Jackson, New South Wales, being an eastern form, occurring in that State, Queensland, Victoria and Tasmania, while *Usacaranx georgianus* (Cuvier, 1833), type locality King Georges Sound, Western Australia, is restricted to that State and South Australia.

5. *Trachurus mccullochi* Nichols, 1920 is here added to the Tasmanian list.

KEY TO CARANGIDAE RECORDED FROM TASMANIA

1. Dorsal fin continuous. Dark bars (5-7) on body . . . . . *Naucrates ductor*
   Dorsal fins separate. No dark bands on body 2
2. Lateral line without keeled scutes. Pectoral about half head . . *Seriola grandis*
   Lateral line with keeled scutes. Pectoral subequal to or longer than head 3
3. Keeled scutes < 40 (20-26), in hind part of lateral line only. .*Usacaranx nobilis*
   Keeled scutes > 40 (68-85), along whole length of lateral line . 4
4. Keeled scutes 74-85, lateral line curving slowly down behind pectoral, P. 1,24. Gill rakers on lower anterior arch 30. Dark greenish blue above . . . . . *Trachurus declivis*
   Keeled scutes 68-73, lateral line curving abruptly down behind pectoral, P. 1,21. Gill rakers on lower anterior arch 38. Yellowish green above . . . . . *Trachurus mccullochi*

Genus *TRACHURUS* Rafinesque, 1810

Trachurus Rafinesque, 1810, CARATT. N. GEN. SICIL., p.41. Type-species, *Trachurus saurus* Rafinesque = *Scomber trachurus* Linné.

Trachurus mccullochi Nichols, 1920

Trachurus mccullochi Nichols, 1920, *Bull. Amer. Mus. Nat. Hist.*, 42, p. 479. New name for *Trachurus declivis:* McCulloch, 1915; not *Trachurus declivis* Jenyns, 1841. Type locality: Mouth of Wide Bay, Queensland, Investigator Strait, South Australia *(Endeavour)*.

Material

An example, *Ls* 283 *Lt* 335, Tamar estuary, north coast, 26 February 1978, Mr M. Watson, Q.V.M. Reg. No. 1978/5/63. First record for Tasmania.

Meristic characters

D. I (procumbent), VIII; I 33 (31+2). A. II, 29 (27+2). V. I, 5. P. I, 21. C. 20 (main rays). Lateral line scutes 27+7+38=72. Gill rakers on lower anterior arch 38. Where relevant these counts fall within the extremes of the ranges for 10 specimens in McCulloch's rather brief account of the *Endeavour* material on which Nichols (1920) without giving other details, based his species. The Handbook (Munro, 1960) notes two procumbent dorsal spines; only one was here detected.

Dimensions as *TLs*

Total length 1184, length to end of middle caudal rays 1078. Length to origin, termination of first dorsal 343, 481, of second dorsal 527, 926, of anal 541, 926. Length to pectoral origin 283, total length of fin 300, length of longest (5th) ray 256. Length to ventral origin 318, total length of fin 159 (for lengths of rays and spine see below). Head 283, snout 99, eye 67, interorbital 67. Length to vent 505. Depth at opercular border 212, at first dorsal origin 219, at vent 219; maximum depth 219; depth of caudal peduncle 36.

Proportions

Several proportions usually cited in specific diagnoses extend outside accepted limits as represented by the ranges given in the Handbook, here shown in parentheses.

Depth in length to end of middle caudal rays (caudal fork) 4.92 (4-4.4), or 4.56 in *Ls* or 5.40 in *Lt*. Head in length to caudal fork 3.81 (3.7-3.9), or 3.54 in *Ls*, or 4.19 in *Lt*. Eye 4.21 (3-3.4) in head, or 1.47 (1-1.4) in snout, equal to interorbital. Scutes 2.88 (3-3.4) in depth of body. First dorsal base 7.26 in *Ls*, or 2.90 in second dorsal base, or 4.87 in anal base. Pectoral 3.33 in *Ls*, or 1.06 head, or 1.89 ventral.

Head, length to vent, length to caudal base (*Ls*)

In a loglog plot these three basic dimensions are significantly linear (t = 21.948*) on 1,2,4.

Log L = 0.9114 log N + 0.4257; predicted (measured) lengths, mm, 79 (80), 148 (143), 278 (283).

Dorsal spines

The spines increase in length to the 3rd then they become progressively shorter. Formulations for length and serial or inverse serial numbers are set out below, the plotting being loglog.

A = {1-3}. Log L = 0.2285 log N + 1.5321. Predicted (measured) lengths, mm, 34.1 (33.7), 39.9 (40.1), 43.8 (43.0). With t = 5.185 the line is not formally significant, failing to reach P 0.10 (6.314).

B = {8-4}. Log L = 0.8912 log N^1 + 1.0015; t = 23.954***; 10.0 (10.0), 18.6 (18.1), 26.7 (27.9), 34.5 (35.9), 42.1 (42.0).

Ventral rays and spine

The ventral rays are somewhat unusual in increasing in length from 1st — farthest from spine, see Part XIX (1974) — to 5th; in a more common pattern 4th exceeds 5th. The loglog length-number graph is highly significant at t = 20.411***.

Log L = 0.3229 log N + 1.4121; predicted (measured) lengths, mm, 25.9 (25.9), 32.3 (31.7), 36.8 (37.5), 40.4 (41.0), 43.4 (42.7).

Location of fins

The locations of the dorsal and anal fins and their terminations (at the same level), together with caudal origin are satisfactorily specifiable by the first degree equation resulting from the graphing on a loglog grid of the lengths to these points against the integral values 3,5,9 (one entry for two fins), 10.

Log L = 0.8959 log N + 1.5592; t (d.f.2) 100.530***; predicted (measured) lengths, mm, 97 (97), 153 (153), 259 (262), 285 (283).

Family ANTHIIDAE

In their provisional classification of living teleosts Greenwood *et al.* (1966) subsume Anthiidae and no fewer than 18 other nominal families in Serranidae. As remarked in Part XXII (1976) in some observations on a Tasmanian example of *Acanthistius serratus* (Cuvier, 1828) the Serranidae as thus recognized with about 600 species constitutes an unwieldy assemblage, and there would seem to be tenable grounds for some subdivision of it. The acceptance here of Anthiidae is in line with its use by most Australian authors, e.g., Munro (1961, 1967), Whitley (1962), Scott *et al.* (1974): Marshall (1964) recognizes five Australian subfamilies of Serranidae, placing several species noted below in Hyperplectroninae.

The number of species included in Tasmanian faunal lists and incidental additions to these has now grown from two to six. In both his catalogues Johnston (1883, 1891) listed (a) *Callanthias allporti* Günther, 1876, (b) *Caesioperca rasor* (Richardson, 1839) (as *Anthias rasor*). Lord (1923, 1927) added (c) *Caesioperca lepidoptera* (Bloch & Schneider, 1801) (rendered *lepidotera* in later list), and these three species occur also in Lord and Scott (1924). Species (d) *Lepidoperca tasmanica* Norman, 1937, 'off Tasmania', placed by its author in Serranidae (1937) is probably to be considered an anthiid (it was apparently so regarded by Whitley, who in his Australian name-list (1964) entered it between species of *Anthias* and *Callanthias*). The Tasmanian occurrence of (e) *Anthias pulchellus* Waite, 1889 was reported by Olsen (1958); an additional record is noted below. Species (f), *Hypoplectrodes nigrorubrum* (Cuvier, 1828) is here added to the local list, the species on which are keyed below.

KEY TO ANTHIIDAE RECORDED FROM TASMANIA

1. Dorsal rays < 12 (10-11). Dorsal spines 10; regularly increasing in length backward. Spinous dorsal base ≥ 2 soft base. Anal base ≥ head. Lateral line exceptionally high, its distance from dorsal profile at level of vent < 1/10 (about 1/15) depth of body there; posterior portion close to dorsal profile of caudal peduncle . . . . . *Callanthias allporti*
   Dorsal rays > 12 (16-22). Dorsal spines 10, rarely 11; not regularly increasing in length backward. Spinous dorsal base < 2 (about 1-1½) soft base. Anal base < (about 1/3-2/3) head. Lateral line not exceptionally high, its distance from dorsal profile at level of vent > 1/10 (about 1/6-1/8) depth of body there; posterior portion close to middle of caudal peduncle . 2
2. Dorsal deeply notched. Caudal convex. Body with dark subvertical bands . . . . . *Hypoplectrodes nigrorubrum*
   Dorsal not deeply notched. Caudal truncate or emarginate. Body without dark subvertical bands 3
3. Dorsal rays < 18 (16-17). Lateral line < 46 (36-44). Pectoral reaching beyond anal origin. Eye about 3 in head. 4
   Dorsal rays > 18 (19-22). Lateral line > 46 (49-70). Pectoral not reaching beyond anal origin. Eye about 4 in head 5
4. Dorsal spines 3rd - 7th subequal; 10th spine subequal to 4th. Caudal emarginate. Small dark spot on spinous dorsal; ovoid black spot on soft dorsal present or absent; no spots on spinous dorsal. . . . . *Anthias pulchellus*
   Dorsal spines 3rd - 7th noticeably decreasing in length backward; 10th spine about half 4th. Caudal truncate. Numerous small dark spots on spinous dorsal, no ovoid black spot on soft dorsal . . . . . *Lepidoperca tasmanica*
5. Dorsal spines 10. Pectoral rays < 16 (13-15, modally 14). Lateral line < 60 (49-55). Posterior portion of preorbital border convex. Black vertical bar at or near pectoral tip, about below end of spinous dorsal, present or absent; no black spot behind pectoral tip. Head with 3 blue bars above, to, below eye . . . . . *Caesioperca rasor*
   Dorsal spines 10 or 11. Pectoral rays ≥ 16 (modally 16). Lateral line > 60 (65-70). Posterior portion of preorbital border concave or straight. No black vertical bar at or near pectoral tip; a more or less rounded black spot behind pectoral tip. No blue bars on head near eye. . *Caesioperca lepidoptera*

Genus *HYPOPLECTRODES* Gill, 1863

Hypoplectrodes Gill, 1863, *Proc. Acad. Nat. Sci. Philad.* (1862), p.238. Type-species, *Plectropoma nigro-rubrum* Cuvier.

Hypoplectrodes nigrorubrum (Cuvier, 1828)

Plectropoma nigro-rubrum Cuvier, 1828, HIST. NAT. POISS., 2, p.402. Type locality: King George's Sound, Western Australia (Quoy & Gaimard).
Hypoplectrodes nigrorubrum: McCulloch, 1929, *Aust. Mus. Mem.*, 5(2), p.154: Scott Glover & Southcott, 1974, MAR. FRESHW. FISH S.AUST., p.256, fig. on p.256.

Material

Two examples, providing the first records of the species in Tasmanian waters, were received at the Queen Victoria Museum, Launceston from widely separated localities within a few weeks of one another: (a) *Ls* 146 *Lt* 179, Banks Strait (between the north-eastern mainland of Tasmania and Clarke Island and Cape Barren Island), 2 February 1978, Mr B. Bensemann, Reg. No. 1978/5/44, (b) *Ls* 181 *Lt* 219, south-west of Port Davey, south-west coast, in 7 m, 10 April 1978, Mr J. Head, Reg. No. 1978/5/69.

Meristic characters

In this and succeeding sections where two data are given, the first is for the smaller individual (a). D. X, 17 (in (a) last divided to base). A. III, 8 (last divided to base). P. 13/13, 14 (left)/13. V. I, 5. L. lat. 56, 58. L. tr. 4 + *ca* 25. Gill rakers 1-2 + 6. Br. 7.

Dimensions as *TLs*

Length to origin, termination of first dorsal 397, 392, 651, 660, of second dorsal 671, 691, 911, 934, of anal 685, 677, 836, 890. Length to pectoral 384, 370, total length of fin 360, 285. Length to ventral 370, 359, total length of fin 257, 227. Length to vent 671, 657. Head 459, 464. Snout 151, 138. Eye 70, 75. Interorbital (between supraorbital ridges) 35, 25. Depth at front of eye 192, 171, back of eye 247, 227, opercular border 349, 326, vent 329, 315; maximum depth 356, 343, depth of caudal peduncle 133, 125.

Proportions

Head 2.18, 2.15 (*cf.* Munro (1961) 2.6), depth 2.81, 2.92 (Munro 2.75-3) in standard length. Snout measured from most advanced point 3.05, 3.36 in head, 2.16, 1.85 eye; measured from anterior margin of preorbital 5.93, 6.32 in head, 1.11, 0.99 eye (Munro eye 'slightly less than snout'). Eye 6.38, 6.22 in head. Interorbital 2.0, 3.0 in eye (Munro 'eye twice interorbital'). Spinous dorsal base 1.12, 1.10 soft dorsal base, 1.68, 1.54 anal base. Pectoral 1.28, 1.63 in head, 2.78, 3.51 in standard length. Ventral 1.79, 2.05 in head, 3.89, 4.41 in standard length. The relative lengths of the three primary regions head, head plus trunk, head plus trunk plus tail are adequately specified (t = 19.185*, 37.084*) by a loglog plot of them on logs 1,2, 5; with lengths in mm the slopes are 0.4814, 0.4760, the intercepts 1.8334, 1.9272; predicted differ from measured lengths for (a) by a mean of less than 2 mm, for (b) of less than 1 mm.

General observations

No systematic Australian account of this species is noticed by Waite (1921, p.93); some synoptic data are, however, provided in the Handbook (Munro, 1961). The following observations, summarized from a tolerably full account of our material, supplement or emend extant descriptions.

Dorsal profile, described by Scott *et al.* as "evenly arched from the snout to the caudal peduncle", presenting a pronounced hump (evident in the standard figure by Quoy & Gaimard (1824) reproduced by them) followed just in advance of eye by a dip occasioned by a transverse furrow extending laterally to or below level of lower (anterior) nostril and subcontinuous behind with a groove running into supraorbital region, profile here provided by rather strong supraorbital ridges; between eye and first dorsal spine profile gently sigmoid, the posterior convex segment somewhat the longer; thereafter to caudal peduncle in two subequal segments, that under spinous dorsal the flatter. Ventral profile to shortly in advance of pelvics not far from straight; thereafter to caudal peduncle virtually a single sweep, rate of curvature increasing caudad.

Maxilla to 0.2, 0.4 eye (Munro middle; Scott *et al.* 'almost to posterior border', as depicted in figure). Subvertical portion of border of preoperculum with small

stout acute spinules, about two score in (b), fewer in (a); somewhat sinuous inferior border with three obscurely pointed angles, each the site of an antrorse spine, only the anterior one conspicuous and projecting. Operculum with two spines, upper larger pointed obliquely upward, its tip failing to reach border of fleshy lobe by about length of spine, lower pointed obliquely downward barely reaching border.

Trunk and tail covered with ctenoid scales, most rather large, somewhat smaller on ventral surface particularly in advance of ventrals, still smaller on nape. Snout, lips, whole under surface of head naked, most of remainder with small or very small scales. Small scales extending on to first dorsal, most notably as a digitiform set 2-3 wide at base on proximal one-third or half of spine; covering lower one-third of soft dorsal, briefly contiguous proximally then continuing as separate subvertical series modally of 6-8 scales; continuing briefly on to base of anal; forming a backwardly convex patch on basal one-sixth or one-fifth of caudal; extending on to pectoral base, apparently absent on concealed under surface.

A scale from near middle of flank subelliptical, diverging from subrectangular mainly as result of difference in outline between lateral borders, one much more rounded posteriorly, so coming to lie at one end of the major axis, length exceeding that of minor axis by about one-sixth of latter. Sinuous asymmetrical hind border with a band, subequal in width throughout most of its length, of mostly ovoid or subrectangular platelets, arranged in 1-3 rows, modally in 2 rows and then disposed alternately close together or even contiguous; along the border about three score tolerably stout subconical recurved spinules, typically arranged (some irregularity may occur laterally) in two alternate rows of two sizes, the larger arising from the interval between the members of the outer row of plates, the shorter (unlike the secondary spines in *Anthias pulchellus* not differing greatly in bulk) arising shortly externad of this, near level of proximal one-fourth or one-fifth of larger spine, their bases thus in line with members of inner row of platelets.

General course of lateral line close to parallelism with dorsal profile, swinging away from it slightly in advance of first dorsal and posteriorly below second dorsal, closest approach to profile about an eye diameter from it; on caudal peduncle parallel with superior border, in (a) a little nearer to it than to inferior border, in (b) equidistant from profiles. Tubules simple, variable in length modally extending about half length of scale.

Numerous small pores covering lateral surface of head in front of level of hind border of orbit, and in a broad band extending back from eye not far short above of dorsal profile and continuing forward into interorbital, bounded below by a line at level of inferior orbital border; ceasing on operculum in vicinity of bases of spines; much more conspicuous in (b) than in (a).

Teeth in upper jaw in a narrow band, villiform, in hinder part of jaw; anteriorly 2 patches of moderate size, briefly disjunct at the symphysis, small externally in general increasing markedly in size inward, the largest, a number of which are depressible, many times as long as the smallest. Teeth in lower jaw much as in upper with the addition of several stout somewhat recurved canines near middle of jaw; in (a) 4 left, 3 right, in (b), 3, 3. Vomerine teeth in a V-shaped band of some 5-7 rows; in (a) much larger in side of jaw, subequal to middle-sized anterior jaw teeth; in (b) noticeably smaller than this. Palatine teeth rather small, anteriorly mainly in 2 series, posteriorly in 3 or 4.

Dorsal fin originating above hinder part of operculum, about at level of upper insertion of branchiostegal membrane, shortly behind pectoral origin, the latter barely behind ventral origin. Anal originating below first or second dorsal ray. Pectoral extending to anal origin, ventral to as far in advance of vent as anal origin is behind vent.

Rays and spines

(i) Character. Dorsal spines long, rather slender, acute, recurved (somewhat less so than in standard figure); membrane between them moderately excavate. First two and last dorsal rays simple, others divided for about half their length, the ramal tips acute, slender, almost filamentous. Anal rays divided more than once, at least 4 modally 8 branches, tip more or less spatulate. All pectoral rays other than simple first — i.e., uppermost, see Part XIX (1974, p.218) — flattened through most of their length and noticeably expanded distally; greatest width of middle ray about half an eye diameter, at about that distance from tip; this ray bilaterally symmetrical throughout its length, rays flanking it expanded distally more on outer than on inner border, this expansion more extensive on lower 8th-12th rays than on upper 3rd-6th. The ventral rays exhibit an interesting departure from the modal perciform pattern. The ray next to the spine (in our notation 5th) instead of being elongate, slender, ending in a single point or a small number of points, is unusually wide and is sheared off on the preaxial side in such a way as to present an oblique combined lateral and terminal border, being lateral inasmuch as it accounts for the whole free margin beyond the spine tip or about half total length of the ray, being terminal inasmuch as it is constituted by the tips of the 6-8 rami, the branches being virtually parallel and closely apposed throughout their length. A similar but less extensive sheared off laterotermínal border, one-fifth or one-sixth of total length, is presented by the adjoining ray on its preaxial side, continuous with that of its neighbour. In other rays the terminal elements, modally 8, decrease in height postaxially in the usual fashion. Primary bifurcation of caudal rays modally followed by two divisions; uppermost and lowermost of the major rays showing some resemblance to 5th and 4th ventral rays in having a rounded oblique externodistal border, about one-sixth length of ray, contributed to by all branches.

(ii) Size. In fish possessing 3 anal spines there appear to be two common length patterns — in one the successive spines exhibit marked increments (length frequently specifiable by $L = bN^k$, where L is length, N serial number), while in the other the second spine (sometimes noticeably stouter than others) either exceeds the third, as in the present species, or is but little shorter than it. Lengths, mm, of spines in (a) 10.4, 19.1, 18.1, in (b) 11.0, 19.0, 18.8.

The lengths of the dorsal spines, dorsal rays, anal rays present a similar overall pattern, comprising in a loglog plot of length and serial number a linear ascendant set with the sequence number N increasing caudad or in pectoral downward, followed by a descendant set with the sequence number N^1 increasing cephalad or in pectoral upward. Such sets may intersect. Usually the set $\{N\}$ includes fewer members than $\{N^1\}$, but in the pectoral they here, with intersection, include the same number. It has been noted in earlier contributions that in a number of species the ventral rays 1-4 — first ray defined in Part XIX (1974, p.248) as that furthest from spine — are such that their logarithmic values give a linear graph when plotted on logs 1-4. In species examined earlier it was found that while in some cases a plot of ray 5 on log 5 and spine on log 10 gave a tolerable approximation to linearity when taken with ray 4 on log 4 as before, in other instances the point for ray 5 regularly stood above a line joining ray 4 and spine. On a basis of symmetry a trial has been made using the present data with rays 4, 5 on logs 4, 5 and with the abscissal coordinate for spine arithmetically as far beyond log 4 as log 4 is beyond log 1, i.e., at log 16: for both specimens $P < 0.02$.

The relevant regression equations $\log L = k \log N$ (or N^1 or N^*) + $\log b$ with associated data are set out in table 2; damage to some ray elements precluding measurement renders some sets incomplete. The symbol N^* denotes an arbitrary (other than sequential) integral number or set of numbers.

TABLE 2

HYPOPLECTRODES NIGRORUBRUM (CUVIER, 1828). LENGTH-POSITION PATTERNS OF FIN SPINES AND RAYS

Series	Specimen	Set	Log L	t	Predicted (measured) lengths, mm
Dorsal spines	(a)	A={1-3}	0.9731 log N + 0.8709	23.162*	7.4(7.5), 14.6(14.2), 21.6(22.0)
		B={10-4}	0.2618 log N^1 + 1.1574	33.955***	14.4(14.3), 17.2(17.5), 19.2(18.8), 20.7(20.9), 21.9(22.0), 23.0(22.8), 23.9(23.9)
	(b)	B={10-4}	0.4277 log N + 1.1002	33.159***	12.6(12.5), 16.9(16.9), 20.2(20.5), 22.8(23.0), 25.1(24.6), 27.0(27.9), 29.0(28.2)
Dorsal rays	(a)	A={1,2,4,5}	0.2159 log N + 1.2308	35.176***	17.0(16.9), 19.8(20.0), 22.9(22.9), 24.1(24.0)
		B={17-14}	0.2232 log N^1 + 1.1724	15.725**	14.9(15.0), 17.3(17.1), 19.0(18.9), 20.3(20.5)
	(b)	A={1-5}	0.2219 log N + 1.2942	17.338***	19.7(19.8), 23.0(22.5), 25.1(25.0), 26.8(27.0), 28.1(27.9)
		B={17-14}	0.3050 log N^1 + 1.2348	21.569**	17.1(17.2), 21.2(21.0), 24.0(24.4), 26.1(26.0)
Anal rays	(a)	A={1-3}	0.0832 log N + 1.4148	44.843*	26.0(26.0), 27.5(27.5), 28.5(28.5)
		B={8-4}	0.3329 log N^1 + 1.2099	18.563***	16.2(16.2), 20.1(19.9), 23.0(22.7), 25.4(25.0), 27.3(28.1)
	(b)	A={1-3}	0.0805 log N + 1.4332	50.173*	27.1(27.1), 28.7(28.7), 29.6(29.6)
		B={8-4}	0.2444 log N^1 + 1.3336	41.436***	21.6(21.4), 25.5(25.6), 28.2(28.0), 30.3(30.0), 31.9(32.3)
Pectoral rays	(a)	A={1-7}	0.3549 log N + 1.3514	52.124***	22.5(22.5), 28.7(28.9), 33.2(33.1), 36.7(36.1), 39.8(39.5), 42.4(43.1), 44.8(44.9)
		B={13-7}	0.5033 log N^1 + 1.2360	52.008***	17.2(17.0), 24.4(24.8), 29.9(29.5), 34.6(35.0), 38.7(38.4), 42.4(43.1), 45.9(44.9)
	(b)	A={1-7}	0.3393 log N + 1.3687	50.246***	23.4(23.5), 29.6(29.1), 33.9(33.9), 37.4(38.0), 40.4(40.5), 42.4(43.0), 45.2(44.8)
		B ={13-7}	0.5360 log N^1 + 1.2075	50.709***	16.1(16.2), 23.4(23.2), 29.1(29.0), 33.9(33.8), 38.2(38.4), 42.1(43.5), 45.8(44.6)
Ventral	(a)	A= {1-4}	0.4458 log N + 1.2286	38.793***	16.9(16.9), 23.1(23.0), 27.6(28.0), 31.4(31.1)
		B={4,5, spine}	− 0.3542 log N*+1.7078	57.252*	31.1(31.1), 28.9(29.0), 19.1(19.1)
	(b)	A={1-4}	0.4770 log N + 1.2543	44.884***	18.0(18.0), 25.0(25.0), 30.3(30.0), 34.8(35.1)
		B={4,5, spine}	− 0.4096 log$N$*+1.7948	42.194*	35.3(35.1), 32.2(32.5), 20.0(20.0)

L = length of element, mm, N = serial number of element counting caudad in dorsal, anal, towards spine in ventral, from uppermost ray in pectoral, N^1 = serial number counting in reverse direction, N* = arbitrary enumeration (see text). Specimen (a) standard length 146 mm, Banks Strait (Mr B. Bensemann), (b) standard length 181 mm, southwest of Port Davey (Mr J. Head).

Coloration

After preservation in formalin ground color of both examples ranging from ivory to pale yellow, the larger with most of scales above midlateral line (other than those involved in cross bars) with a largest dark grey spot, making this region overall decidedly darker than lower part. Specimen (b): characteristic pattern of 5 cross bars evidently having experienced some fading but still better preserved than in (a); indication of short oblique bar from near first dorsal origin, good dark bar to midlateral line from just behind middle of spinous dorsal, two fairly persistent bars below soft dorsal extending about three-quarters down flank, moderately well preserved narrow bar across caudal peduncle; upper half of head moderately deep brown, continued down as a curved bar bordering mouth; a darker rounded spot, a little smaller than eye, immediately behind orbit; indications of three longitudinal series of darkish spots (when first seen approaching orange) across soft dorsal, two or three transverse lines of spots across caudal, several scattered darkish spots on anal, some dappling proximally on spinous dorsal produced by ungual spots of microscopic greyish punctulations on invading scales (markings on fins not noticed by Munro or by Scott *et al.*). Specimen (a): bars less distinct; no markings visible on fins; dark brown spot somewhat smaller than eye just behind eye.

Genus *ANTHIAS* Bloch, 1792

Anthias Bloch, 1792, NAT. AUSL. FISCHE, 6, p.97. Type-species, *Labrus anthias* Linné.

Anthias pulchellus Waite, 1899

Anthias pulchellus Waite, 1899, *Aust. Mus. Mem.* 4(1), p.77, pl.12. Type locality: Bungaree Norah to Wollongong, New South Wales; 68-143 m.

Tasmanian occurrence

This species does not appear in any local catalogue, and the Check-list (McCulloch 1929, p.155) gives New South Wales only. A single example trapped in a net-covered craypot attached to a long line in 370 m west of King Island reported, without comment on the specimen, in this journal by Olsen (1958, p.157) affords the only published primary record for this State. A specimen *Ls* 156 *Lt* 194 taken off Eddystone Point, east coast, in 140 m by Mr Shane Downe in August 1978, Q.V.M. Reg. No. 1978/5/94, is here noted.

Meristic characters

Br. VII. D. X, 16. A. III, 8. V. I, 5. P. 16. C. 17 (8+1+8) main rays. L. lat. 45. L. tr. 5/15. Gill rakers on lower limb of anterior arch 24.

Dimensions as *TLs*

Length to origin, termination of first dorsal 314, 641, second dorsal 654, 881, anal 638, 881. Length to pectoral origin 308, to ventral origin 333. Total length of pectoral 397, of ventral 275. Length to vent 619. Head 353. Snout 96. Eye 109. Interorbital 93. Depth at front of eye 199, back of eye 321, opercular border 397 (maximum), vent 391; depth of caudal peduncle 115.

Proportions

Data in parentheses are those for the type material (Waite, 1899); no ranges are given in the Handbook (Munro 1961, p.172), entries for proportions merely being Waite's values rounded to first decimal place. Head 2.84 (2.8), depth 2.52 (2.47) depth of caudal peduncle 8.67 in *Ls*. Snout 3.67 (4.6), eye 3.24 (3.6) in head. Interorbital 1.17 (1.2) in eye, 3.79 (3.75) in head. Measured between parallels, spinous dorsal base 1.44 (from Waite's figure about 1.3) soft dorsal base, or 1.34 (figure about 1.6) anal base. Pectoral 1.13 in head ('longer than head by one tenth'), ventral 1.28 (1.4) in head.

General features

A good general account and an illustration have been provided by Waite, but the species does not appear to have been the subject of further investigation; the following observations report some additional data or render extant information more precise, and call attention to some differences exhibited by our material.

Upper profile of head decidedly more concave overall than in figure, and particularly so above hinder part of eye. Lower jaw projects beyond upper by full anteroposterior extension of its lip. Fully scaled almost square-ended maxilla reaching to below 0.4 eye (Waite first fourth of orbit), its distal breadth twice its shortest distance from eye. Posterior nostril, contrasted with anterior with 'a skinny rim' as 'a simple opening', here with a distinctly elevated rim bordering all but its anterior one-third where a small fold is drawn across the aperture. Only two of the three opercular spines described and figured here recognizable; at site of uppermost only a small obscure skinny process. Along whole length of hind border of preoperculum a series of approximately three score small, contiguous or closely set, somewhat upwardly directed, acute processes, increasing regularly in size downward; along whole inferior border projections, a score or more, in the form of stout subconical spines, many two-cusped, the largest strongest, near the angle, up to 1.5 mm long, length and bulk decreasing regularly forward ("Both limbs of preopercle finely serrated, those at the angle not enlarged"). Serrations not mentioned in Waite's text but more or less clearly traceable in his figure comprising in our specimen an arc of about 15 moderate-sized spines along whole of exposed suboperculum, and a series of some two score, smaller, decreasing in size forward, along border of interoperculum, ceasing at same level as spinules of preoperculum, slightly in advance of middle of eye. The 24 (26) gill rakers on lower limb of anterior arch long slender minutely spinulate along upper border.

Teeth in upper jaw subconical, minute behind increasing in size forward, in somewhat irregular double series anteriorly, becoming uniserial. Inside jaw, separated at symphysis by short edentulous interspace, two mounded areas each bearing several smallish teeth and one very strong, subconical, recurved, acute canine directed slightly inward distinctly backward. Viewed from above, outline of upper jaw comprising paired convex lateral segments and a median concave segment, its arc about one-third eye; at either junction of latter with former a stout subconical canine, subequal to that within mouth, placed quite external of mouth cleft, directed forward and somewhat downward, and when jaws are closed extending over lower lip; round its base a few small teeth. On either side of mandible a subtriangular cluster of teeth in several rows, small internally, minutely tuberculate in front and laterally; behind this some small or very small teeth in 2 or briefly 3 rows extending to middle of jaw, here two recurved canines followed by very small teeth in 1 row. Outside of jaw 2 well separated canines, directed forward and upward, fitting inside external pair in upper jaw. Vomerine teeth minute, in two lateral lobes and one shorter, basally broader forwardly directed lobe, all sides of the figure concave, angles rounded. On each palatine small teeth in a broad band somewhat wider in its anterior half, 5-6 rows here; length some five times width, latter exceeding shortest distance from vomerine series.

Anal base ending level with (figure in advance of) dorsal base. (Some difference in relative lengths of spinous dorsal, soft dorsal anal noted earlier in Proportions). Longest, 4th, dorsal spine 2.0 (2.1) in head, 1.90 (twice) 1st; 2nd 1.4 (1.4) in 4th; 4th 1.1 (almost equal to) 3rd; spines 5th-8th, 26.5, 25.2, 24.5, 22.9 mm (subequal); 9th, 10th 21.1, 18.6 (somewhat shorter). Soft dorsal higher than posterior spines (ditto); longest, 4th (11th) 0.98 (does not exceed) 4th spine. Longest anal spine, 2nd, 1.0 (as long as) 3rd dorsal. Anal rays: longest, 2nd, 1.09 longest dorsal ray, mean length 1.11 mean of dorsal rays (anal rays much longer). Ventral spine 0.95 (slightly longer than) 4th dorsal spine; longest ventral ray (second preaxial, in our notation 4th, in Waite's 2nd) 1.41 (1.4) in head; fin reaching to anal base (failing

to reach vent). Longest pectoral ray, 9th (8th); whole fin 0.96 head (longer than head by one-tenth), reaching to base of 1st (3rd) anal spine.

Scales on whole trunk, tail, head, including branchiostegals, except small area on chin, part of anterior end of maxilla (entire head scaled); extending on to both dorsals to form a sheath reaching on an average about one-third height of fin, but rising higher on some anterior spines; similar but somewhat less extensive sheath on anal with prolongations up the rays; pectoral, ventral scaly in basal one-third or less; in a basal arc on caudal, about a dozen on middle rays (the presence of these scales is in possible contravention of one diagnostic feature of the Anthiidae as recognized by Munro (1967, p.279) namely "Fins without basal scale sheaths"). Waite provides no indication as to presence or absence of an axillary process between ventrals (stated by Munro not to occur in Anthiidae) : in our specimen no definitive process developed, but several somewhat elongated scales forming a small subtriangular group overlapping bases of inner ventral rays on either side and extending briefly backward into interval between fins. Scales on body largest under pectoral, about half an eye diameter, at level of vent two-thirds on caudal peduncle one-third this. On operculum little if at all smaller than on trunk nearby, others on head smaller, on lateral surface decreasing fairly evenly forward, on dorsal surface suffering a rather sudden diminution at level of hind orbital border.

A scale from near middle of flank subquadrangular, dorsoventral extension a little greater than anteroposterior, hind border moderately convex somewhat sinuous, front border barely rounded, rather gently, simply or sinuously curved, approximating backward; posterior field heavily armoured externally with a conspicuous band of three-sided or four-sided platelets or flat spines, disposed in oblique rows in varying numbers, a medial row with 3-6; arising from between outer borders or tips of outer row a series of some 40-60 rather stout, acutely or bluntly pointed recurved spines, their basal widths subequal to their interspaces, their length regularly increasing mediad; the numerous fine wavy striae in the anterior field divided by 11-14 strong radial striae or ridges, the series not extending to anterolateral angles of scale.

Spines and rays

(i) Character. Dorsal spines of moderate length, longest shorter than in *Callanthias allporti*, longer than in *Caesioperca rasor*, rather stout, pungent, in our specimen noticeably more recurved than in Waite's plate. Dorsal rays all divided, last with 2, others modally with 4 but up to 8 sharply pointed rami. Anal rays in general similar to dorsal rays. Pectoral with first and last rays unbranched, pointed; remainder begin to branch near middle of fin, from this point widening, at the same time flattening and becoming further divided, these features becoming increasingly evident with increase in size, longest (9th) ray about 1 mm wide at base with subterminal width of 3 and with 8 rami: fin almost bilaterally symmetrical, with, however, highest ray the 9th; slope of upper border between tips of first and last members 5.0 mm per ray interval, that of lower border 6.3. Ventral rays already divided and redivided at or before middle of their length, distad of this continuing to divide, somewhat irregularly, terminating in a dozen or more fine tips forming a wide fan. Anal spines large stout, basal diameter of largest, second, about one-third eye.

(ii) Size. In most cases spine lengths, in one or more series (often intersecting) in a fin, yield in a loglog plot a linear graph on their serial numbers as abscissal values. Metrical data are set out in table 3. The dorsal rays exhibit a quite unusual feature. In the set {16-5} of the 12 members 3 near the middle of the series (8, 9, 10) are of equal height, those before and behind them descending in height caudad. It is found by trial a very good straight line (t = 44.902***, see table) results when these 3 rays are treated as a single variate with a single abscissal coordinate (log 7) — a circumstance clearly of some, if at present undetermined, significance in the causal interpretation of these widespread length-number patterns.

TABLE 3

ANTHIAS PULCHELLUS WAITE, 1899. LENGTH-POSITION PATTERNS OF FIN SPINES AND RAYS

Series	Set	Log L	t	Predicted (measured) lengths, mm
Dorsal spines	A = {1-4}	0.4746 log N + 1.1625	22.907**	14.5(14.5) 20.2(20.1) 24.5(25.1) 28.1(27.6)
	B = {10-4}	0.2007 log N^1 + 1.2665	373.810***	18.6(18.5) 21.2(21.1) 23.0(22.9) 24.4(24.5) 25.5(25.2) 26.5(26.5) 27.3(27.6)
Dorsal rays	A = {1-4}	0.9761 log N + 1.3710	19.357**	23.5(23.5) 25.1(25.2) 26.2(26.0) 26.9(27.0)
	B = {16-11 (8 9 10) 7-5}	0.3108 log N^1 + 1.0810	44.902***	14.9(15.0) 16.9(17.1) 18.5(18.0) 19.8(19.8) 21.0(20.5) 22.0(22.0 rays 8 9 10) 23.0(23.1) 23.8(24.0) 24.6(25.0)
Anal spines	A = {1 3 2}	0.4259 log N* + 1.2127	61.959*	16.3(16.3) 21.9(22.0) 26.1(26.0)
Anal rays	A = {5-2}	0.2085 log N^1 + 1.3532	92.040***	22.6(22.6) 26.1(26.1) 28.4(28.0) 30.1(30.1)
	B = {8-5}	0.1717 log N^1 + 1.2608	15.217**	17.8(17.0) 20.1(19.8) 21.5(21.7) 22.6(22.6)
Pectoral rays	A = {2-9}	0.4046 log N + 1.3579	28.626***	22.8(23.4) 30.2(30.0) 35.6(34.2) 40.0(39.1) 43.7(43.8) 47.1(47.0) 50.1(52.0) 52.9(53.0)
	B = {15-9}	0.5937 log N^1 + 1.2338	59.080***	17.1(17.0) 25.9(26.0) 32.9(32.6) 39.0(39.8) 44.5(45.5) 49.6(49.9) 54.4(53.0)
Ventral rays	A = {1-4}	0.4621 log N + 1.2708	21.066**	18.7(18.9) 25.8(25.1) 31.0(30.8) 35.4(36.0)
	B = {4,5, spine}	− 0.2314 log N*+1.6951	41.594*	36.0(36.0) 34.2(34.1) 26.1(26.1)

L = length of element, mm, N = serial number of element counting caudad in dorsal, anal, towards spine in ventral, from uppermost ray in pectoral, N^1 = serial number counting in reverse direction, N* = arbitrary enumeration (see text). Specimen standard length 156 mm, off Eddystone Point, east coast (Mr Shane Downe).

Among the ventral rays it is found the relevant length is not, as is usual, that of the longest ramus but that of the middle ramus (or mean of two medial rami). It is of some interest to observe that this value is not necessarily identical with the mean length of the two outermost branches, since to conform with the general broad curve of the outspread fin the degree of obliquity of the ray tip, relative to main antero-posterior axis of fin, varies from ray to ray. In the formulation for ventral rays 4, 5 and spine number ordinates are 4, 5, 16.

Lengths of body regions

The dimensions head, head + trunk, head + trunk + tail that in some other species are linear in a loglog plot on 1,2,3 here yield a satisfactory straight line (t = 35.818*, better than P 0.02) on 1,2,4, the slope being 0.7519, intercept 1.7441; predicted (measured) lengths, mm, 55 (55), 93 (95), 157 (156).

Coloration

On being thawed out after receipt in a frozen state the fish was an almost uniform reddish orange, varied only by some indeterminate yellowish areas on the head. After preservation in alcohol the whole specimen is pale cream in ground color. Each of the scales of three or four rows above the lateral line bears a more or less rounded dusky spot. The large black blotch occurring on anterior half of soft dorsal and just encroaching on spinous dorsal delineated in Waite's figure and stated by him to be present only in some individuals is here absent.

Specific status

While there seems little doubt the present specimen is referable to *Anthias pulchellus*, several differences from the definitive description of that species are worthy of notice. The most striking is the more forward position of anal relative to dorsal in our specimen, in which first anal spine originates virtually below (< 1 mm behind) insertion of last dorsal spine, whereas Waite's figure shows it below second dorsal ray. From the third backward dorsal spines as figured are virtually straight; here they are noticeably recurved. Waite discussed the relations between *A. pulchellus* and *A. hypselosoma* Bleeker, 1857 — equating with the latter a specimen washed up on the beach at Lord Howe Island described by Ogilby (1888) as *A. cichlops*, a reidentification later being made formally by him (Waite 1904a) and maintained in his Lord Howe catalogue (1904b) — and *A. pleurotaenia* Bleeker, 1857, the former being noted as being recorded from Lord Howe Island, the latter from "the north-east coast of Australia": of these only *A. pleurotaenia* appears in the Check-list (McCulloch 1929, p.155) and in the name-list of Whitley (1964, p.42). It may be noted in passing that in the recent annotated check-list of the fishes of Lord Howe Island (Allen *et al.* 1976, the Serranidae by Hoese) includes (p.395) an entry for *Pseudanthias* sp., in the synonymy of which are placed both *Anthias cichlops* : Ogilby, 1888 (non Bleeker) and *Pseudanthias hypselosoma* : Waite, 1904 (*non* Bleeker).

Some half dozen differences enumerated by Waite as distinguishing his species from *A. hypselosoma* as interpreted by him are valid also for our specimen. However, the preopercular spines present some difficulties. In his general description he expressly observes 'those at the angle not enlarged' and in his discussion differentiates *A. pulchellus* by "the sub-equal character of the preopercular serrations". As reported above in the Tasmanian specimen the projections on the preopercular margin are noticeably larger near the angle than elsewhere, being here quite stout spines of moderate size. While 3 opercular spines are reported for *A. pulchellus*, 2 only are clearly identifiable in the present fish.

E.O.G. Scott

Genus *CALLANTHIAS* Lowe, 1839

Callanthias Lowe, 1839, *Proc. zool. Soc. Lond.*, 7, p.76. Type-species, *Callanthias paradisaeus* Lowe.
Anogramma Ogilby, 1899, *Proc. Linn. Soc. N.S.W.*, 24(1), p.179. Type-species, *Callanthias allporti* Günther.

Callanthias allporti Günther, 1876

Callanthias allporti Günther, 1876, *Ann. Mag. Nat. Hist.* (4), 17, p.390. Type locality: Tasmania.
Callanthias platei australis Ogilby, 1899, *Proc. Linn. Soc. N.S.W.*, 24(1), p.173. Type locality : Sydney Market and Port Jackson.
Callanthias platei : Waite, 1899, *Aust. Mus. Mem.*, 4(1), p.80 (not *Callanthias platei* Steindachner, from Chili).

Remarks

This elegant species, based on material forwarded from Hobart to the British Museum over a century ago by Morton Allport (compiler of the first local list of fishes; still in ms) is seldom encountered in this State, though not infrequently trawled off the southern mainland coast. Its specific status, in particular its relation to *Callanthias platei* Steindachner, 1898 from Chile, has received more attention from Australian quthors — e.g., Waite (1894, 1899), Ogilby (1899), McCulloch (1911), the last-named calling attention to variations in proportion with overall size — than has the general delineation of the species, no good general account of it apparently being available in the local literature. Some morphometric data not elsewhere recorded are here provided and extant notices are extended and/or emended in respect of several features; some consideration is given also to length-number patterns of fin rays and spines.

Material

Two examples, (a) *Ls* 157 *Lt* 200, off Eddystone Point, east coast, 140 m, August 1978, Mr Shane Downe, Q.V.M. Reg. No. 1978/5/95, (b) *Ls* 195 *Lt* (including prolonged caudal rays) 250.5, Binalong Bay, east coast, 3 January 1977, Mr D. Wright, Q.V.M. Reg. No. 1977/5/1.

Meristic characters

In this and succeeding sections where two data are recorded the first is that for the smaller individual (a). D. XI, 10; XI, 11, last divided to base. A. III, 10; III, 11, last divided to base. V. I, 5. P. 21. C. 17 (8+1+8) main rays. L. lat. 46, 43. L. tr. 4-5/16-18. The counts of 11 dorsal rays and 11 anal rays in (b) exceed those given in the original description (Günther, 1876) and in recent Australian catalogues by Munro (1961), Scott *et al.* (1974).

Dimensions as *TLs*

Length to origin, termination of first dorsal 264, 226, 592, 557, of second dorsal 618, 577, 841, 866, of anal 551, 510, 850, 840. Length to pectoral origin 287, 237, to ventral origin 299, 278. Length, total, of pectoral 239, 237, of ventral 280, 222 (hence in (a) ventral in (b) pectoral the longer). Length to vent 532, 485. Head 274, 237. Snout 48, 52. Eye 95, 80. Interorbital 88, 88. Depth at front of eye 185, 144, back of eye 287, 260, opercular border 354, 330, vent 357, 309; maximum depth 363, 330; depth of caudal peduncle 159, 129.

Proportions

Entries in parentheses are those for the type material. Head 3.65, 4.22 in (one-third of), depth 2.75, 3.03 in (one-fourth of) standard length. Snout 5.73, 4.56 in, eye 3.07, 2.97 in (two-sevenths of) head. Interorbital 1.01 in, 0.91 of eye or

3.12, 2.71 in head. Maximum depth of caudal peduncle 1.72, 1.84 in head. Spinous dorsal base 1.47, 1.14 soft dorsal base, 1.10, 1.00 anal base, measured between parallels, or 1.41, 1.06 and 1.09, 1.01 measured with dividers. Pectoral 1.15, 1.00 ventral 0.87 of, 1.07 in head, or 4.19, 4.22 and 3.57, 4.51 in standard length.

General features

The following observations supplement Australian treatments of the species.

Dorsal profile with a markedly more concave segment than that depicted in the standard figure by Waite (1894, pl.2) extending from about midway between upper lip and eye about to level of middle of orbit. Lower jaw projecting slightly. Preorbital narrow, its least width subequal to that of upper jaw. Opercular, preopercular, preorbital borders entire. Operculum with two acute spines, lower about at level of middle of eye, twice or more as long as upper. On account of truncation of snout premaxilla more or less L-shaped; scaleless, dentigerous throughout its entire length. Maxilla wholly squamous, extending to below 0.4, 0.3 eye.

Head with numerous pores (not noticed in original description), variably developed in the two specimens, at times on two sides of same individual, including (a) about a dozen mostly small behind and upwards from upper part of hind border of orbit, (b) a circumorbital ring of about a score, very variable in size, in specimen (a) two very large on preorbital at about 6 o'clock (left side viewed), (c) two or three pairs on dorsum of snout in advance of middle of eye, (d) a series along preopercular border including three large on lower limb and one large shortly above angle, (e) four on each mandible. Nostrils apparently represented by a pair of small short tubular structures somewhat nearer to level of front of upper lip than to level of front of orbit, and a pair of apertures just outside orbit, left at about 10 o'clock (left side viewed).

Teeth in upper jaw in an elongate linguiform band widest in front, about 8 rows there, cardiform; externad of this band a single row of some 10-20 (number varying on right and left sides) of much larger though still small conical or peglike teeth inserted on lip near its inner border; on squared-off front of snout in (a) 4 large and several smaller teeth in lip, slightly outside mouth cleft, directed upward and forward, in (b) a similar set but teeth considerably smaller. In lower jaw on either side of symphysis a subtriangular patch of cardiform teeth followed by a single series variable in size and including 3 or 4 canines; near either end of the transverse anterior segment of the jaw 1 or 2 large externally set teeth directed upward and forward. (Only the forwardly pointing teeth of the lower jaw are mentioned by Günther). Vomerine teeth in a forwardly convex arc, almost all in a single row, in (a) of at least two sizes, the larger very large; subcontinuous on each side with a series, single or very briefly double anteriorly, of smaller, in (a) very much smaller, palatine teeth. Tongue edentulous.

Scales covering whole of body, whole of head except lips; most large, exposed hind border under base of pectoral 0.6 eye; on head decreasing in size forward, elsewhere decreasing backward; not extending on to fins other than caudal, there forming a conspicuous basal arc and extending up rays almost to tip.

A scale from the middle of the flank is subquadrangular, the hind border moderately the front barely rounded, lateral borders almost straight slightly diverging forward. The exposed border bears about four score stout straight pungent spines, about their own basal diameter apart; along the whole or most of the array a smaller spine, from a quarter to a third as wide, is intercalated between each pair of primary spines, originating near the middle of their lengths, terminating about on a level with them; in the anterior field the wavy concentric striae very numerous closely set in short transverse series separated by some two dozen strong radial striae, the series

extending just round the anterolateral angles; each band of concentric striae surmounted externally by a hyaline lunule, the whole anterior border thus being crenulate.

The unusual course of the lateral line at once distinguishes this species from other anthiids occurring in our waters; shorter anterior segment of 6-7 scales slightly proconcave or slightly proconvex, rising at an overall angle of about 50° from near upper attachment of operculum to below 3rd or 4th dorsal spine, posterior of some 35-40 scales following course of base of dorsal only 3-4 scales from it to end of fin, continuing parallel with dorsal border of caudal peduncle, distant from it by one-sixth or one-seventh of depth here. In the preserved material the line appears to consist of a series of shallow grooves commonly filled with gelatinous-looking material; at the hind end of each scale an opening, in (a) large slitlike, length usually from a third to half interspace, in (b) smaller, more rounded.

A marked difference in the relative lengths in (a) and (b) of the two dorsals has been recorded above in section headed "Proportions", ratio of longer base (spinous) to shorter being 1.3 times greater in former. In (b) anal origin about below antepenultimate, in (b) below penultimate dorsal spine. Soft dorsal in (a) much more elevated than in (b), longest ray about twice, more than thrice in total dorsal base (in standard illustration about two and a half times); a similar discrepancy characterizes the two anal fins. (This situation is in direct contrast to that reported for *Endeavour* material by McCulloch (1911, p.52), who found height of vertical fins increasing with size of fish, specimens less than 1.3 cm to about 23 cm in length having longest anal ray 7.3, 5.04, respectively, in length of fish). In (b) laid-back dorsal just fails to reach origin of uppermost caudal ray, in (a) extends beyond it by a little more than half depth of stout peduncle. Rounded pectoral to level of vent; obtuse ventral to 1st anal spine or 1st anal ray. Lower caudal lobe slightly longer than upper; in (a) both lobes ending in a normal point, in (b) 3rd ray from uppermost and 3rd ray from lowermost of those attaining hind border of fin produced in a filamentous process, the longer (upper) half length of head.

Between ventral bases a well developed elongated triangular axillary process, widest and thickest anteriorly where it is somewhat cushion-like, reduced to a flattish membrane in its distal one-third; thickly sheathed in front with scales, in places in more than a single layer. This structure has not previously been reported for this species: indeed, an axillary process is stated by Munro (1967, p.279) not to occur in Anthiidae.

Rays and spines

(i) Character. Dorsal spines long, tolerably stout, pungent; the membrane between them barely excavate reaching almost to their tips. All dorsal rays divided nearly to base; secondary division not beginning till 3rd (a) or 4th (b) ray, then only in posterior ramus; division more active throughout in posterior portion of ray field, an earlier branch either not dividing at all (with resultant odd number of terminals) or dividing higher than corresponding later branch. Anal spines long, slender; in (b) tip surmounted by short lanceolate fleshy process (lost in (a) by mutilation?). In anal rays division greater and/or earlier in the hinder rami; only one division in 1st and 2nd rays, with a third ramus arising from the second in 3rd, 4th, also in (a) 5th ray, the anterior ramus not dividing till 6th, 5th ray, 8 terminals being developed only near end of fin. In ventral terminals, starting from ray furthest from spine, 8, 10, 10, 6, 4 in (a), 6, 10, 8, 6, 4 in (b).

(ii) Size. With lengths, mm, (a) 11.7, 22.0, 28.1 (b) 12.0, 20.1, 24.0, the 2nd and 3rd anal spines are of noticeably greater absolute length in the smaller individual; while the ratio of 2nd to 3rd is significantly the same in (a) and (b), the ratio of 1st to 3rd is numerically much greater in (a) 1:2.05 than in (b) 1:1.68.

The dorsal spines, dorsal rays, anal rays and ventral rays in general exhibit an exponential relation between length and serial number of insertion, $L = bN^k$. In three sets the coordinates for one or more terminal or subterminal elements fail to fall on the linear loglog plot for the remaining elements (always by excess magnitude). These elements, met with only in (a), are first dorsal spine, first and last dorsal rays, last two anal rays. In (a) dorsal spine 4 is imperfect. Data for the length-number patterns found are set out in table 4.

Coloration

The original description notes merely 'uniform reddish (in spirits)', and this account has not been greatly amplified in local texts, Scott *et al.* (1974, p.257) for instance stating 'colour reddish in spirit, probably bright reddish in life'. The following is a summary of some observations made on specimen (a) immediately after its being defrosted on receipt at the Museum. General color of dorsal and lateral surfaces more or less uniform pale yellow with some touch of orange or reddish; in some areas a silvery tinge, this becoming the prevailing color on ventral surfaces of trunk and tail. From eye back across head and on to pectoral base reddish purple; two rounded silver spots at front of dorsal surface of truncate snout, diameter subequal to interspace; upper jaw greenish yellow; lower jaw pale yellowish with some rosy tinge, a median silvery spot at symphysis; isthmus white. Both spinous and soft dorsals light yellow, the last few rays with some rose; a pink oval spot, major axis longitudinal, near the bases of nearly all spines and rays; a few very short longitudinal reddish dashes at outer border of both fins, these not forming a regular linear series. Anal much like dorsals but somewhat brighter; a small amount of pinkish between last two rays; an oval or rounded pinkish spot at bases of spines and rays; very narrow imperfect distal border of reddish. Pectoral bright slightly greenish yellow. Ventral yellowish, deeper than pectoral. Caudal pale greenish yellow; an extensive whitish lunule covering tips of all rays except two or three upper and two or three lower, its medial extension about one-fourth of middle rays.

In the 1977 specimen the details of the pattern were more fully preserved and color as a whole was more intense. General color of trunk and tail below about midlateral line pearly white fading to white below. Above about midlateral line below soft dorsal and posterior one-third of spinous dorsal orange, below rest of dorsal (and extending on to head) approaching magenta with orange spots; a large ovoid spot of deep magenta between eye and dorsal profile; pupil black; iris yellowish with some white, surmounted by magenta crescent. On hind half of caudal peduncle a more or less hemispherical region of grey extending forward from caudal base; at back of this area a median longitudinal patch of chrome yellow; vertically above this at upper profile two pairs of small grey spots; vertically below at lower profile, partly extending on to fin, an irregular patch of grey. Ventral surface whitish or pearly, posteriorly with yellow spots. Dorsal fins yellowish; soft dorsal with chrome yellow or orange blotches, narrowly margined with magenta. Anal mostly white, last four rays with orange spots, narrow magenta distal border. Pectoral white, some tinge of orange. Ventral white proximally, with pink flush in distal half. Caudal largely pink; most of hind portion from shortly in advance of level of end of middle caudal rays orange red; set in this one longitudinally oval of chrome yellow near upper border and one near lower; extending back from middle three-quarters of fin base an irregular splash of chrome yellow narrow behind to a point at a little more than halfway to end of middle caudal rays.

TABLE 4

CALLANTHIAS ALLPORTI GÜNTHER, 1876. LENGTH-POSITION PATTERNS OF FIN SPINES AND RAYS

Series	Specimen	Set	Log L	t	Predicted (measured) lengths, mm
Dorsal spines	(b)	A={1-4}	0.5278 log N + 1.0303	27.638*	10.7(10.6) 15.6(15.8) 19.4(19.2) 22.6(22.0)
		B={11-5}	0.0905 log N^1 + 1.4300	49.035***	26.9(26.7) 28.7(28.9) 29.7(29.8) 30.5(30.8) 31.1(31.0) 31.7(31.5) 32.1(32.0)
	(a)	B={10,9,7,5}	0.2712 log N^1 + 1.3364	18.966**	21.7(21.8) 29.2(29.0) 33.5(33.0) 35.3(36.0)
Dorsal rays	(b)	A={1-4}	0.0911 log N + 1.4915	13.341*	31.0(31.0) 33.0(33.0) 34.3(34.4) 35.2(35.1)
		B={11-5}	0.1604 log N^1 + 1.3933	13.224*	24.7(25.4) 27.6(27.2) 29.5(29.0) 30.9(31.0) 32.0(31.8) 33.0(33.2) 33.7(34.2)
		B={11-4}	0.1640 log N^1 + 1.3921	16.800*	24.7(25.4) 27.7(27.2) 29.5(29.0) 31.0(31.0) 32.1(31.8) 33.1(33.2) 34.0(34.2) 35.1(34.7)
	(a)	B={9-3}	0.3901 log N^1 + 1.3336	18.078***	48.5(47.0) 46.0(46.5) 43.4(44.5) 40.4(41.4) 37.0(35.9) 33.1(33.2) 28.2(28.2)
Anal rays	(b)	A={1-4}	0.1060 log N + 1.4649	4.701*	29.2(29.3) 31.4(31.0) 32.8(33.0) 33.8(33.8)
		B={11-4}	0.1144 log N^1 + 1.4239	53.256***	26.5(26.5) 28.7(28.9) 30.1(30.0) 31.1(31.1) 31.9(31.9) 32.6(32.4) 33.2(33.2) 33.7(33.8)
	(a)	A={1-3}	0.0927 log N + 0.3412	19.238*	33.7(33.9) 35.9(35.2) 37.2(37.7)
		B={4-9}	0.2676 log N^1 + 1.5059	12.926**	24.3(24.7) 27.3(26.3) 29.3(29.0) 31.1(31.1) 32.7(33.0) 34.0(34.3)
Ventral rays	(b)	A={1-4}	0.4379 log N + 1.3212	56.118***	20.9(21.0) 28.4(28.5) 33.9(33.2) 38.4(39.0)
	(a)	A={1-4}	0.3386 log N + 1.2861	65.727***	19.3(19.1) 24.4(25.0) 28.0(28.1) 30.9(30.5)

L = length of element, mm, N = serial number of element counting caudad in dorsal, anal, towards spine in ventral, N^1 = serial number counting in reverse direction. Specimen (a) standard length 157 mm, off Eddystone Point, east coast (Mr Shane Downe), (b) standard length 197 mm, Binalong Bay, east coast (Mr D. Wright).

Observations on some Tasmanian Fishes : Part XXV

Genus *CAESIOPERCA* Castelnau, 1872

Caesioperca Castelnau, 1872, *Proc. zool. acclim. Soc. Vict.*, 1, p.49. Type-species, *Serranus rasor* Richardson.

Caesioperca rasor (Richardson, 1839)

Serranus rasor Richardson, 1839, *Proc. zool. Soc. London*, p.95. Type locality: Port Arthur, Tasmania (Lemprière).

Material

Eleven examples: (a) *Ls* 125, Bell Bay wharf, Tamar estuary, north coast, 1978, R. McBain, Queen Victoria Museum Reg. No. 1978/5/54; (b) *Ls* 125, Sandy Beach, Tamar estuary, 19 March 1978, C. Curtis, Reg. No. 1978/5/64; (c) (d) (e), *Ls* 161, 168, 170, Low Head, north coast, 16 February 1975, R.L. Askeland, Reg. No. 1975/5/24; (f) *Ls* 172, Croppies Point near Bridport, north coast, 28 December 1973, scuba divers, Reg. No. 1974/5/145; (g) *Ls* 173, south of Orford, east coast, 8 May 1977, D.M. Wood, Reg. No. 1977/5/19; (h) *Ls* 176, Binalong Bay, east coast, 1 August 1977, Wright, Reg. No. 1977/5/36; (i) *Ls* 176, 1.2 km off Low Head, north coast, 2 March 1974, P.M. Hart, Reg. No. 1974/5/101; (j) *Ls* 192, George Town, Tamar estuary, in graball net, shallow water, 18 July 1968, Cannon, Reg. No. 1968/5/30, (k) *Ls* 200, Sidmouth, Tamar River, 1 July, 1967, A.P. Perkins, Reg. No. 1967/5/13.

Remarks

This species, based on material from Port Arthur sent to the British Museum from Tasmania by J.J. Lemprière (1796-1852), one of the Colony's early collectors and since encountered in Victoria (where the examination of the only example to come under his notice led Castelnau (1872, p.49) to institute his genus *Caesioperca*) and South Australia, is more common, at any rate in the northern parts of the State than the rather similar but more widely ranging *C. lepidoptera* (Bloch & Schneider), which extends northward to New South Wales and westward to Western Australia. Johnston (1891, p.24) rated it as common during the winter season. Lord & Scott (1924, p.58) set the length at 200-250 mm, the upper extreme being adopted also by Scott *et al.* (1974, p.258), while the Handbook (Munro 1961, p.172) gives a somewhat lower maximum, 215 mm: our largest individual, (k) has a total length of 250 mm. It is stated by Scott *et al.* to be taken in depths of 55-75 m, while the Handbook puts the range deeper at 85-110 m; however, most of our material has been collected in quite shallow water, one specimen (k) being caught 15-20 km from the sea.

Examination of the material listed above makes apparent the existence of considerably more variation in some meristic and morphometric values than has hitherto received recognition, the figures here found transgressing at one or both extremes all the ratios for which synoptic values are given in the Handbook, as well as two counts there given.

Meristic characters

D. X, 20 (1 specimen), 21 (8), 22 (2). A. III, 8 (1), 9 (10), last ray divided to base. V. I, 5. P. 13/14 (3), 14/14 (4), 15/15 (4); outside Handbook range 14-15, Castelnau 13. L. lat. 49 (1), 50 (1), 52 (2), 55 (3), 56 (2), 57 (1); outside Handbook range 49-56, Castelnau 56. C. 16 (1), 17 (10); Castelnau 15.

Dimensions as *TLs*

The principal dimensions are set out in table 5, in which the first line, standard length, is recorded in millimetres, all other entries being in millesimals of standard length.

TABLE 5

Caesioperca rasor Richardson, 1839. DIMENSIONS OF 11 TASMANIAN EXAMPLES

Dimension	Range	$\bar{x}$	V
Standard length, mm	125-200	167.1± 7.078	14.0 ± 3.1
Length to tip of upper caudal lobe	1227-1284	1256.3± 5.481	1.4 ± 0.3
Length to tip of lower caudal lobe	1210-1273	1240.2± 5.803	1.6 ± 0.3
Length to tips of middle caudal rays	1131-1197	1158.8± 5.474	1.6 ± 0.3
Length to first dorsal origin	267-341	305.1± 6.207	6.7 ± 1.4
Length to first dorsal termination	560-665	595.5± 9.163	5.1 ± 1.1
Length to second dorsal origin	575-672	611.2± 8.695	4.7 ± 1.0
Length to second dorsal termination	853-898	872.8± 4.325	1.6 ± 0.4
Length to anal origin	630-723	662.7± 8.102	4.1 ± 0.9
Length to anal termination	800-864	822.6± 6.256	2.5 ± 0.5
Length to vent	595-694	627.0± 7.852	4.2 ± 0.9
Length to pectoral origin	276-304	289.9± 4.225	4.2 ± 0.9
Length to ventral origin	278-368	325.8± 7.052	7.2 ± 1.7
Length of pectoral, total	300-375	327.6± 6.658	6.1 ± 1.3
Length of ventral	185-239	205.5± 4.728	7.6 ± 1.6
Head	270-304	290.6± 3.131	3.5 ± 0.8
Snout	68.2-93.8	78.0± 2.550	10.8 ± 2.3
Eye	60.5-78.4	67.4± 1.713	8.4 ± 1.8
Interorbital	83.9-102	91.0± 1.769	6.4 ± 1.4
Depth at front of eye	163-239	208.4± 7.940	12.6 ± 2.7
Depth at back of eye	238-318	284.1± 5.774	6.7 ± 1.4
Depth at opercular border	335-381	351.8± 4.560	4.3 ± 0.9
Depth at vent	202-364	318.2±13.118	13.7 ± 3.0
Maximum depth	342-403	370.9± 6.327	5.7 ± 1.2
Depth of caudal peduncle	114-131	123.8± 1.757	4.7 ± 1.0

First line standard length, mm, all other lines permillages of standard length.

Proportions

Each of the following entries comprises range, mean with standard error, coefficient of variation with standard error.

Head 3.26-3.70, 3.43±0.0397, 3.8±0.8 in standard length (Munro 3.5, Castelnau three and a half in total length). Greatest depth 2.48-2.95, 2.71±0.0487, 5.7±1.2 in standard length (M. 2.6-2.8, C. three and one-third in total length). Depth at vent 2.75-3.40, 3.06±0.0595, 6.4±1.4 in standard length. Depth of caudal peduncle 7.59-8.74, 8.09±0.114, 4.7±1.0 in standard length; 2.21-2.66, 2.36±0.0413, 5.8±1.1 in head. Snout 3.17-4.27, 3.77±0.103, 9.1+1.9 in head. Eye 3.88-4.75, 4.38±0.0811, 6.1±1.4 in head (Munro 4-4.5, Castelnau four times); 1.02-1.50, 1.17±0.0443, 12.5±2.8 snout (Munro eye equal to snout). Eye 1.13-1.53, 1.37±0.0403, 9.8±2.1 in interorbital (Munro eye less than interorbital). Pectoral 2.89-3.25, 3.06±0.0349, 3.6±0.8 in standard length; 1.04-1.20, 1.12±0.0139, 4.1±0.9 head (Munro 1.2-1.3).

Coloration

After preservation much of the original color has been lost, most of the specimens being overall not far from uniform brownish, regularly darker however in the upper one-fourth or one-third. The spots on the individual scales of the lower half of the flank persist as well defined darker areas in most of the larger examples, but are wholly missing in the smallest, (a) and (b) which are noticeably lighter than the rest and virtually immaculate. Traces of the scattered spots below and in advance of the pectoral are recognizable in several individuals, as also are the markings on the caudal and anal fins (not apparent in the illustrations reproduced in the South

Australian catalogues of Waite (1921) and of Scott (1962). The Handbook mentions only two blue streaks near the eye, but the three bars beginning near the tip of the snout, one extending above, one below the eye, the other ceasing at the orbit near the middle of its anterior border that are noted and figured in Scott *et al.* are present in all our examples save the smallest two. The facultative black bar (not shown in either of the standard figures) occurs on both sides in 7 examples and on one side (and there only on 2 scales) in 1. Castelnau's description of it as 'lozenge-shaped' is generally apt. It varies considerably in extent in different individuals, sometimes to some degree on the two sides, involving 1-3, modally 2 scales horizontally, 2-12 vertically: the pectoral may just fail to reach it, partly or wholly overlap it or occasionally extend briefly beyond it.

Scales

The extensive invasion by scales of the vertical fins has been adequately described by Castelnau. Scales are found also on the pectoral base, extending in a single series of from about a dozen to about a score up the middle rays for as much as one-third their length, but usually being restricted to fewer than half a dozen on the lateral rays; a similar row sheaths the basal half of each of the ventral rays and the spine. A short broad somewhat linguiform axillary process, not noted in available accounts, is present, consisting of several large scales, the hinder median much enlarged, subtriangular; total length about two-thirds eye diameter. The Handbook states "Head including maxilla and mandible scaly"; scaleless areas are the lips, most if not all of the preorbital, the branchiostegal (but as in allied species not the rays), the contrast of its smooth forward extension flanking the isthmus and the strongly scaled tumid course of the latter being very striking.

A scale from the midflank is of the same general type as that described above for *Hypoplectrodes nigrorubrum*; about three score strong spines in a single series on each side, in two alternate series in middle half or more of posterior border; 12-13 strong radial ridges, outermost just failing to reach anterosuperior and anteroinferior angles; at base of spines 3-4, occasionally 5 rows of platelets or incipient truncate spines, set alternately; very shallow lunules lacking the fine closely set wavy striae constituting crenulate overall nearly straight anterior border.

Comparison with other accounts

Attention has been drawn above to notable discrepancies between some published meristic and morphometric variates and those found in the present material. Some additional differences call for comment. Maxilla "reaches below hind half of eye" (Handbook); in our material it never reaches even to middle of eye, modally to one-third or less, in some individuals barely reaching orbit. "The denticulations of the praeoperculum very fine on its outer edge, but becoming much larger towards the angle; the lower edge is also crenulated" (Castelnau), "preoperculum finely serrated behind and below, without antrorse spines" (Handbook). In the present specimens the upper four-fifths of the hind border is beset with between two and three score very small almost contiguous tolerably acute spines; in the lower fifth progressively increasing in size to angle and round it on to hind one-third or somewhat more of inferior border, the rest of this wholly lacking spines, either bluntly wavy throughout or including in its hinder part several broad subtriangular subspinous crenulations. "Praeorbital strongly ciliated" (Castelnau): conventionally this is to be interpreted as referring to the free inferior border. This border is not ciliated; it exhibits in its posterior half some 6-10 strong flutings that continue down to the margin to end in a scalloped curve. However, the upper border and indeed the whole arc of the lower half of the orbital margin is minutely denticulated with fleshy pointed processes. Scott *et al.* report "a single weak opercular spine", the Handbook "2 strong spines". Normally two fairly strong spines are present, upper larger at base of soft dorsal lobe, lower below it by about a pupil diameter; one or both sometimes ending bluntly or in 2-3 small points; however, in several specimens lower spine is quite rudimentary,

detectable with some difficulty.

Lengths of primary regions

For the geometric means of the 11 individuals length of head, length to vent, length to caudal base (standard length) are significantly linear (t = 60.875*) in a loglog plot on 1,2,3.

Log L = 1.1213 log N + 1.6812; predicted lengths (measured lengths back-calculated from geometric mean) 48.0 (48.2), 104.4 (103.1), 164.5 (165.6).

Relative lengths of vertical fin bases

Striking increases in the lengths of the second dorsal base and anal base relative to length of first dorsal base are found. In the smallest two individuals the soft dorsal is 1.65, 1.36 in the spinous, in the largest two 0.96, 0.91: for the whole series r = 0.809 (z = 1.125), t = 4.135**. In the smallest two specimens anal base is 2.26, 2.21, in the largest two 1.86, 1.47 in first dorsal base; r = 0.700 (z = 0.867), t = 2.941*.

Caesioperca lepidoptera (Bloch & Schneider, 1801)

Epinephalus lepidopterus Bloch & Schneider, 1801, SYST. ICHTH, p.302. *Perca lepidoptera* Forster, Ms. Type locality: New Zealand - South Island, *fide* Whitley 1968, p.53.

Anthias richardsonii Günther, 1869, *Proc. zool. Soc. Lond.*, p.429. Type locality: Tasmania.

Scorpis hectori Hutton, 1872, CAT. FISH. N.Z., pp. 4, 106, pl.1, fig.4. Type locality: Milford Sound.

Material

Two examples: (a) *Ls* 183, Swan Island, Bass Strait, August 1975, C. Dallas, Q.V.M. Reg. No. 1975/5/204, (b) *Ls* 208, Eaglehawk Neck, south-east coast, 1 March 1975, P. Last, Reg. No. 1975/5/46.

Remarks

This species is not to be found in either of the first two published Tasmanian lists (Johnston 1883, 1891). Lord & Scott (1924, p.53) comment, "Johnston (P. & P. Roy. Soc. Tas., 1882 [= 1883], p.109) drew attention to the similarity between *C. rasor* and *S. hectori* of Hutton. Hutton's species has since been shown to be identical with *C. lepidoptera*, which Johnston apparently confused with the following species, as he omitted *C. lepidoptera* from his list." It seems probable Johnston was following the lead of Macleay, who in his Australian catalogue (1881a, p.312) more than hinted at the identity of Günther's species, which has Tasmania as type locality, with *C. rasor* (not with *C. lepidoptera*, which he fails to mention); in his first list Johnston consistently refers to Macleay's work, citing that author's species number. The present species thus first appears in a local publication in Lord's first list (1923: second binomen spelt *lepidotera* in 1927 list). The butterfly perch, recorded from all Australian States other than Queensland (and New Zealand, type locality), is usually taken by trawling. It reaches a length of about 300 mm.

Meristic characters

Here and elsewhere smaller individual cited first. D. X, 21. A. III, 9, III, 10, in both last ray divided to base. V. I, 5. P. 17/17, 16/16. C. 18. L. lat. 65, 67. Gill rakers on lower anterior arch 30, 28. The data of the Handbook (Munro 1961, p.171) are here extended by the higher number of pectoral rays in one specimen (17, *cf.* 16).

Dimensions as *TLs*

Length to tip of upper caudal lobe 1240, 1264, to tip of lower lobe 1273, 1250, to end of middle caudal rays 1148, 1159. Length to origin, termination of first dorsal 257, 257, 615, 587, of second dorsal 623, 625, 907, 889, of anal 678, 640, 852, 832. Length to vent 612, 615. Length to origin of pectoral 261, 278, of ventral 322, 313. Total length of pectoral 399, 409, of ventral 240, 243. Head 273, 289. Snout 65.6, 62.5. Eye 76.5, 67.3. Interorbital 76.5, 67.3. Depth at front of eye 150, 159, back of eye 265, 260, opercular border 383, 388, vent 377, 370; maximum depth 388, 394; depth of caudal peduncle 121, 120.

Proportions

The synoptic values of the Handbook, several of which are here transgressed, are given in parentheses. Head 3.66, 3.47 (3.3-3.6), maximum depth 2.58, 2.54 (2.25-2.5), depth at vent 26.5, 27.0 in standard length. Depth of caudal peduncle 8.24, 8.32 in standard length, 2.44, 2.40 in head. Snout 4.17, 4.62 (3-3.5) in head, 1.17, 1.08 in eye (eye slightly greater than snout). Eye in interorbital 1.00, 1.00 (equal). Pectoral 1.46, 1.42 (contrast subequal to) head. Ventral 1.14, 1.19 in head.

General observations

Dorsal contour of head much more sinuous than as depicted in either the figure in the Handbook or that in Scott *et al.* Maxilla to 0.7, 0.3 eye (Handbook hind half), its greatest width about twice its shortest distance from eye. Pectoral to first, to second anal spine; extending to, slightly beyond, front of characteristic dark spot at level of second, third dorsal ray, involving 7, 9 scales longitudinally, 3-5 vertically. Anterior nostril with a large irregular fleshy flap arising from hind half of margin; posterior larger, with low rim. A scale from midflank of same general type as one from same site of *C. rasor*, but proportionally longer and with lateral borders virtually straight, parallel instead of convex, approximating posteriorly; spines on posterior border rather smaller; outer bounding radial striae straight, instead of swinging upward or downward posteriorly. "Preoperculum finely serrated behind and below, without antrorse spines" (Handbook): spinules numerous, very small at upper end of hind border, increasing downward, rather suddenly so in lowest one-fourth, one-third and in hind half of inferior border, there directed strongly backward, rest of inferior border without spines.

As in *C. rasor* there are indications of increases in the lengths of the second dorsal and anal bases relative to the length of the first dorsal base with increase in size of fish, the first-named being (a) 1.31 (b) 1.25, the second (a) 2.05 (b) 1.71 in the third. In a loglog plot length of head, length to vent, length to caudal base (standard length) are significantly linear (t = 95.385**, 130.005**) on 1, 2, 3; slopes of graphs 1.1791, 1.1274, intercepts 1.6977, 1.7754, predicted (measured) lengths, mm, 50(50),113(112), 182(183), 69(60), 130(228), 206(208).

As noted above there was some early confusion between this species and *C. rasor*, a confusion that Scott (1962, p.229) observed still persists in South Australia in some quarters. The two forms are usually separated by (a) greater number of lateral line scales in present species (54-65, *cf.* 49-55), (b) general color pattern, (c) constant instead of facultative occurrence in *C. lepidoptera* of a dark mark on flank, and the location of this beneath the front of the second dorsal in that species instead of beneath the end of the first dorsal (the sole criterion given by Macleay (1881a, p.312) for the separation from *C. rasor* of Günther's *Anthias richardsonii*); (d) consistent presence in present species of 10 dorsal spines, some examples of *C. rasor* having 11.

Additional differences, to some of which attention does not seem to have been called previously, include the following (*C. lepidoptera* noted first): (e) more pectoral rays (16-17, 13-15), (f) eye equal to (less than) interorbital, (g) preoperculum squamous (wholly or mainly scaleless), the free border not (rather strongly)

bowed near middle, its hind half straight or slightly concave (convex), (h) lowest point of hind border of preoperculum behind (at or in advance of) level of hind border of orbit, (i) opercular and subopercular borders entire (some denticulation on opercular angle and on suboperculum), (j) horizontal section of lateral line on caudal peduncle beginning in advance of (at or behind) insertion of last dorsal ray; there are also differences, noted above, in the scales.

Coloration

As preserved (a) mainly tolerably even yellowish, some areas somewhat silvery, lateral line anteriorly purplish, traces of three orange stripes, lowest best preserved about one-third eye diameter in width, following ventral profile about a snout length above it, vertical fins beyond more or less orange basal scaly sheath whitish, pectoral briefly orange proximally, thereafter whitish, ventral very pale yellowish, caudal pale orange in proximal two-thirds, distally white; (b) darkish brown above, yellowish below with most scales with a small brown spot, vertical fins beyond yellowish basal sheath somewhat dusky, second dorsal darkest, pectoral rays greyish darkening distally, membrane yellowish, ventral very pale yellowish, darkening domewhat distally, caudal rays whitish or yellowish, membrane somewhat greenish yellow: no discrete markings on the fins in either specimen.

Abnormal structure.

The smaller individual presents on its left side a quite exceptional structure in the form of an almost straight line of some 15 smallish almost contiguous tubules (suggestive of a lateral line, though not of that of this species), extending backward and somewhat downward from the tip of the soft opercular lobe, two-thirds of an eye diameter below the origin of the lateral line proper, for a distance of a little less than length of head.

Head, length to vent, length to caudal base

In this species with the lengths of the primary regions head, head + trunk, head + trunk + tail as ordinates the loglog plot is linear (t = 95.385**, 130.005**) on the integers 1, 2, 3, the best straight lines having slopes 1.1791, 1.1208, intercepts 1.6977, 1.7754; predicted (measured) lengths, mm, 50(50), 113(112), 182(183); 60(60), 130(126), 206(208).

Family ECHENEIDAE

Genus *REMORA* (Linné, 1758)

Echeneis remora Linné, 1758, SYST. NAT., ed. 10, p.260. Type locality: In Pelago Indico.

Material

Three examples, *Ls* (a) 83 (b) 87 (c) 98 mm, collected 30 km east-south-east of Wineglass Bay (Thouin Bay), east coast, between 12 and 17 January 1978 by Mr John Head (Q.V.M. Reg. No. 1978/5/32), from about a score accompanying a shark: 'families' of juveniles or adults accompanying a single host appear to be not uncommon (Cressy and Lachner, 1970).

Remarks

Two examples, *Ls* 341, 355, taken at a depth of 460 m 40 km east of Eddystone Point, east coast, on 5 February 1976, attached to a luth, *Dermochelys coriacea* (Linné, 1776) were the subject of fairly extensive observations in Part XXIII (1977, p.164). The present specimens, only about one-fourth as long, exhibit several interesting differences in proportion and other features.

TABLE 6

DIMENSIONS OF *Remora remora* (Linné, 1758)

Dimensions of three specimens from 30 km east-south-east of Wineglass Bay (Thouin Bay), east coast, between 12 and 17 January 1978 (Mr John Head) and two specimens from 40 km east of Eddystone Point, east coast, 5 February 1976 (Mr A.W. Yeats) : first line standard length in millimetres, all other lines as millesimals of standard length.

Dimension	1978			1976	
	(a)	(b)	(c)	(a)	(b)
Standard length, mm	83	87	98	341	355
Total length	1162	1149	1164	1205	1231
Length of disc between free margins	361	366	367	321	327
Width of disc between free margins	169	174	168	138	133
Width of lamina series	133	116	133	92	94
Pectoral, length to origin at front of base	264	246	265	251	259
Pectoral, length to insertion of median ray	286	269	286	273	273
Pectoral, length of fin (1976 longest ray)	169	168	172	170	165
Length to origin of ventral	264	253	280	279	262
Length of ventral (1976 longest ray)	164	172	163	145	148
Length to origin of second dorsal	614	575	592	693	611
Length to termination of second dorsal	867	931	908	924	887
Length to origin of anal	608	598	598	592	606
Length to termination of anal	880	897	899	908	896
Length to vent	583	574	572	548	566
Head	273	264	270	252	251
Snout, from tip of lower jaw	120	115	108	112	125
Snout, from tip of upper jaw	83	93	86	99	106
Eye	48	54	51	26	27
Interorbital, across dorsal surface of head	146	151	148	166	166
Interorbital, across ventral surface of head	118	116	107	-	-
Width at front of disc	84	79	82	111	107
Width at front of eye	148	149	163	161	158
Width at opercular border	169	174	173	185	180
Width at back of disc	157	152	153	161	166
Width at vent	123	115	112	141	132
Width, maximum	171	174	174	176	179
Depth of caudal peduncle	62	57	54	72	68

Meristic characters

P. 28. C. about 20 main rays. The thickness of the membrane of the vertical fins makes an accurate ray count a matter of some difficulty even in the best circumstances (Strasburg 1964, Scott 1977): in the present instance the fish are in a rigid condition with the fins wholly collapsed (at some stage unduly dehydrated?) and a count is not feasible. All three have 18 disc laminae (earlier examples 18, species range 16-20).

Dimensions

A series of dimensions as millesimals of standard length is set out in table 6, the corresponding entries for the larger individuals being noted also for comparison. The smaller fish exhibit, in relative terms, much larger eye, narrower interorbital, marginally larger head, noticeably lesser depth at vent and at caudal peduncle, shorter caudal, wider disc, wider lamina series.

Head, length to vent, length to hypural joint

It was found for the 1977 examples that on a loglog plot these three regions are significantly collinear (t 18.57*, 14.2*) on the integral coordinates 1, 2, 3. This relation obtains here; dimensions below as millesimals of standard length (1977, in mm); measured lengths in parentheses :

(a) Log L = 1.1838 log N + 2.4252; t = 20.610*; 260(270), 605(583), 1020(1000).
(b) Log L = 1.2014 log N + 2.4159; t = 14.214*; 261(264), 599(576), 975(1000).
(c) Log L = 1.1676 log N + 2.4287; t = 14.299*; 268(273), 603(572), 968(1000).

It will be observed the plotted (measured) value for length to vent is systematically somewhat lower than the predicted value; this is so also in the earlier specimens. The mean slope here, 1.1843, is less than that, 1.2448, found before.

Relative lengths of disc and pectoral

It has been shown by Maul (1956) and Strasburg (1964) the length of the sucking disc relative to that of the pectoral is diagnostic — greatest in *Remoropsis brachypterus* (Lowe, 1839), least in *Rhombochirus osteochir* (Cuvier,); large in present species — but, as the latter author has shown its systematic significance is qualified by differential growth in the two features. The increase with age of the relative excess of pectoral over disc length in *Remora remora* is indicated by the following data (percentage of standard length) : *Ls* 83, 87, 89 (present sample) 2.4, 2.6, 2.6; *Ls* 240, 6.4 (one specimen, calculated from Strasburg's fig.1); *Ls* 341, 3.55 (1977 material) 6.7, 6.5. Further, Strasburg's scatter diagram shows that for about a score of individuals with an approximate *Ls* range of 50-150 mm the excess is about 0-2.5 mm, modally around 1.5; for the present fish it is 2.0, 2.3, 2.5.

Relative lengths of pectoral, ventral

While in specimens (b), (c) the pectoral extends slightly beyond the ventral, by 0.3, 0.8 mm — in qualitative agreement with the 1977 material, though the extension there, at half, one-third eye diameter, is greater — in (a) the ventral reaches further back by 1.5.

Head in plan

As with the earlier material, the outline of the head (total outline viewed in plan) is adequately specified by a second degree polynomial. For the largest individual the equation calculated from 10 measurements of width taken at equal intervals along the anteroposterior axis is as follows (N = decile number, proceeding caudad).

$W = 7.4900 + 2.5947\ N - 0.14470\ N^2$; calculated (measured) widths, mm, 9.9 (9.9), 12.1 (11.9), 13.9 (14.0), 15.6 (15.9), 16.8 (17.0), 17.8 (18.0), 18.6 (18.3), 19.0 (18.6), 19.1 (19.0), 19.0 (19.3). R = 0.99991. The third degree equation provides no significant increase in precision of prediction; R = 0.99996.

Outline of disc

Like that of the head the outline of the disc is well represented by a curve in N^2; the subjoined parameters are those of specimen (b), in which the symmetry of the disc is most satisfactorily preserved.

$W = 5.9133 + 3.1315\ N - 0.25758\ N^2$; 8.8 (9.0), 11.1 (11.0), 13.0 (13.1), 14.3 (14.8), 16.1 (15.0), 15.2 (15.2), 15.2 (15.5), 14.5 (15.0), 13.2 (13.2), 11.5 (11.5). R = 0.99967. As for disc outline in the 1977 material (and as for head in plan in both samples) the addition of a cubic term gives no significant gain (here altering only the second decimal places of the constant and the term in N and the third decimal place of the term in N^2, leaving R as given above unchanged).

Length-number pattern of laminae

It was found for the 1977 material that with the lengths of the disc laminae from the most anterior back to the longest (9th, 11th) denoted by L and their serial numbers by N (proceeding caudad), and with the lengths of the remaining laminae denoted by L_1 and their serial numbers (counting cephalad from the hindmost) by N_1,

the following relationships subsist, $L = bN^k$, $L_1 = bN_1^k$, the equations on rectification yielding t for (a) 49.33***, 25.88***, for (b) 143.27***, 11.90***. Comparable calculations have been made here in the case of the largest individual. The two sets intersect at the longest, 11th, lamina, while earlier they had been treated as disjunct.

Log L = 0.3625 log N + 0.7247; t = 15.336***; predicted (measured) lengths, mm, 5.3(5.0), 6.4(7.1), 7.9(8.0), 8.8(9.0), 9.5(9.7), 10.2(10.0), 10.7(10.5), 11.3(11.0), 11.8(11.5), 12.2(12.0), 12.7(13.0).

Log L_1 = 0.3635 log N_1 + 0.7868; t = 10.368***; 6.1(5.9), 7.9(8.1), 9.1(9.4), 10.1(10.4), 11.0(11.0), 11.7(11.7), 12.4(12.0), 12.9(13.0).

For the larger fish of 1977 the gradients are much greater: (a) 20.5223, 12.6108, (b) 24.0869, 12.7766.

It is to be observed that while the dimensions recorded represent lengths direct between right and left ends of the lamina and thus serve to define the overall form of the lamina set, they do not necessarily measure the transverse extent of the comblike teeth, the anterior and the posterior laminae comprising right and left moities set at a wide obtuse angle, whereas towards the middle of the series the two segments approximate to a single straight line, the terminal laminae thus having a somewhat greater dentate extension relative to end-to-end length of the medial laminae.

The denticles are modally set in two well formed continuous lines, one along the anterior one along the posterior border of the lamina; however, some laminae near the middle of the series may include an additional brief or almost complete intercalated line. The fact that in the considerably larger fish examined previously there are modally four linear series of denticles suggests their number may well be a function of age. Denticles along the anterior border here, numbering up to about three dozen, are small, closely set, mamilliform, those along the posterior border longer, distinctly spinose, acute, less numerous.

Coloration

Trunk, tail virtually uniform gunmetal grey; head mostly similar, somewhat lighter more or less brownish on operculum (particularly posteriorly), lighter also on mandible, preorbital. Disc dark greyish briefly margined behind with lighter. Dorsal and anal apparently concolorous with body, Pectoral: (a) blackish in basal one-third, merging into yellowish lightest at tip, (b) mostly very dark grey, lowermost ray somewhat brownish, the extreme tips of some rays touched with yellowish, (c) intermediate between (a) and (b). Ventral blackish, a little lighter distally and along outer margin. No specimen shows any indication of the white lines and spots found in the larger of the 1977 specimens.

REFERENCES

Anon., 1975: In *Aust. Fisher.*, 34(5): 18; article, Hake now Gemfish.

Allen, G.R., Hoese, D.F., Paxton, J., Randall, J.E., Russell, B.C., Stark, W.A. II, Talbot, F.H. and Whitley, G.P., 1976: Annotated checklist of the fishes of Lord Howe Island. *Rec. Aust. Mus.*, 30(15): 365-454, figs 1,2.

Baird, R.C., 1973: Chauliodidae. In FISHES OF THE WESTERN NORTH ATLANTIC. *Mem. Sears Found. Mar. Res.*, 1(6).

Castelnau, F.N., 1872: Contribution to the ichthyology of Australia. No. 1. The Melbourne fish market. *Proc. zool. acclim. Soc. Vict.*, 1: 29-242.

Cressey, R.F. and Lachner, E.A., 1970: The parasitic copepod diet and life history of Diskfishes (Echeneidae). *Copeia*, 1970, 2: 310-318.

Greenwood, P.H., Rosen, D.E., Weitzmann, S.H. and Myers, G.S., 1966: Phyletic studies of teleostean fishes, with a provisional classification of living forms. *Bull. U.S. Nat. Mus. Nat. Hist.*, 131(4): 330-456, pls 21, text figs 1-9, charts 1-32.

Günther, A., 1876: Remarks on fishes, with descriptions of new species in the British Museum, chiefly from Southern Seas. *Ann. Mag. Nat. Hist.*, 17: 389-402.

_____, 1880: Report on the shore fishes ... *Rept Zool. Challenger*, 1(6): 1-74, pls.

_____, 1887: Report on the deep-sea fishes ... *Rept Zool. Challenger*, 22(57): 1-268, pls.

_____, 1889: Report on the pelagic fishes ... *Rept Zool. Challenger*, 31(78): 1-47, pls.

Haedrich, R.L., 1967: The stromateoid fishes: systematics and classification. *Bull. Mus. Comp. Zool.*, 135(2): 31-139, 56 figs.

Herald, E.S., 1953: Family Syngnathidae: pipefishes, 231-278, figs 36-44. In FISHES OF THE MARSHALL AND MARIANAS ISLANDS, L.P. Schultz & Collaborators, *U.S. Nat. Mus. Bull.* 202(1): I-XXXII + 1-685, pls 1-74, figs 1-90.

Johnston, R.M., 1883: General and critical observations on the fishes of Tasmania; with a classified catalogue of all known species. *Pap. Proc. R. Soc. Tasm.* (1882): 54-144.

_____, 1891: Further observations on the fishes and fishing industries of Tasmania; together with a revised list of indigenous species. *Pap. Proc. R. Soc. Tasm.* (1890): 22-46.

Lord, C.E., 1923: A list of the fishes of Tasmania. *Pap. Proc. R. Soc. Tasm.* (1922): 60-73.

_____, 1927: A list of the fishes of Tasmania. *J. pan-Pac. res. Inst.*, 2(4): 11-16.

_____ and Scott, H.H., 1924: A SYNOPSIS OF THE VERTEBRATE ANIMALS OF TASMANIA. Oldham, Beddome & Meredith, Hobart.

McCulloch, A.R., 1909: Studies in Australian fishes. No. 2. *Rec. Aust. Mus.*, 4(4): 315-321, pls 90, 91, text fig. 18.

_____, 1911: Report on the fishes obtained by the F.I.S. 'Endeavour' on the coasts of New South Wales, Victoria, South Australia and Tasmania. Part 1. *Zool. res. Endeavour*, 1(1): 1-87, pls 1-16, text figs 1-20.

_____, 1916: Report on some fishes obtained by the F.I.S. 'Endeavour' on the coasts of Queensland, New South Wales, Victoria, South and Southern Australia. Part 1. *Biol. res. Endeavour*, 4(4): 169-199, pls 44-48, text figs 1,2.

_____, 1922: Check-list of the fish and fish-like animals of New South Wales. Part 3. *Aust. Zool.*, 2(3): 86-130, pls 25-43.

_____, 1929: A check-list of the fishes recorded from Australia. *Aust. Mus. Mem.*, 5(1-4): (part 4, Index, 1930), I-X + 1-534.

Macleay, W., 1881a: Descriptive catalogue of the fishes of Australia. Part 1. *Proc. Linn. Soc. N.S.W.*, 5(3): 302-444.

_____, 1881b: Descriptive catalogue of the fishes of Australia. Part 2. *Proc. Linn. Soc. N.S.W.*, 5(4): 510-629.

Marshall, T.C., 1964: FISHES OF THE GREAT BARRIER REEF AND THE COASTAL WATERS OF QUEENSLAND. Angus & Robertson, Sydney.

Maul, G.E., 1956: Monografia dos peixes do Museu Municipal do Funchal. Ordem Discocephali. *Bol. Mus. Mun. Funchal*, 9(23): 5-75. (n.s.)

Munro, I.S.R., 1957, 1958, 1960, 1961: Handbook of Australian Fishes; issued serially in *Fisheries Newsletter* (now *Australian Fisheries*), published monthly, 1956-1961. Parts here cited. 1957a: part 7, pp. 29-32; vol. 16, part 1. 1957b: 14, 57-60, 16(8). 1957c: 15, 61-64; 16(9). 1958a: 19, 77-80; 17(1). 1958b: 20, 81-84; 17(2). 1958c: 22, 89-92; 17(4). 1958d: 26, 105-108; 17(8). 1958e: 27, 109-112; 17(9). 1958f: 30, 121-124; 17(12). 1960: 31, 125-128; 19(4). 1961: 42, 169-172; 20(12).

_____,1967: THE FISHES OF NEW GUINEA. Department of Agriculture, Stock and Fisheries, Port Moresby.

Nichols, J.T., 1920: A key to the species of *Trachurus*. *Bull. Amer. Mus. Nat. Hist.*, 42.

Norman, J.R., 1937: British, Australian and New Zealand Antarctic Research Expedition: Fishes. *B.A.N.Z.A.R.E.* Rept B, 1(2): 49-88, text figs 1-11.

Ogilby, J.D., 1888: Exhibition of a second specimen of a rare percoid fish, *Anthias (Pseudanthias) cichlops* Bleeker, from Lord Howe Island. *Proc. Linn. Soc. N.S.W.*, 3(2): 741.

_____, 1897: Some Tasmanian fishes. *Pap. Proc. R. Soc. Tasm.* (1896): 69-85.

_____, 1899: Contribution to Australian ichthyology. *Proc. Linn. Soc. N.S.W.*, 24(1): 154-186.

Olsen, A.M., 1958: New fish records and notes on some uncommon Tasmanian species. *Pap. Proc. R. Soc. Tasm.*, 92: 155-159.

Post, A., 1976: Ergebnisse der forschung des F.F.S. 'Walther Herwig' nach Südamerika, 42. *Diretmus* Johnson, 1863 (Beryciformes, Berycoidei, Diretmidae), 2. Morphologie, entwicklung, verbreitung. *Arch. Fisch Wiss.*, 26(2/3): 87-114.

_____ and Hecht, J., 1977: Results of the research cruises of the F.R.V. 'Walther Herwig' to South America, 49. The otoliths of *Diretmus* Johnson (Osteichthyes, Beryciformes, Diretmidae). *Mitt. Hamburg. Zool. Mus. Inst.*, 74: 165-170, figs 1-3.

Quoy, J.R.C. and Gaimard, P., 1824: Remarques sur quelques poissons de mer; descriptions des poissons. In Freycinet, L., VOYAGE AUTOUR DU MONDE DES CORVETTES 'l'URANIE' ET LE 'PHYSICIENNE' PENDANT LES ANNEES 1817-1820, zool., 2: 182-401.

Scott, E.O.G., 1934-1978: Observations on some Tasmanian fishes. Parts I-XXIV; in this journal (except Part XVI, *Aust. Zool.*, 15(2): 160-177, figs 1,2). Contributions here cited. 1953, VI, 141-165, figs 1-4. 1961, X, 49-65, figs 1-3. 1963, XI, 1-31, figs 1-8. 1970, XVII, 33-50, fig. 1. 1974, XIX, 247-292, figs 1,2. 1976, XXII, 157-217, pl. 1. 1977, XXIII, 111-180, figs 1-8, 1978, XXIV, 289-356, figs 1-3.

Scott, T.D., 1962: THE MARINE AND FRESH WATER FISHES OF SOUTH AUSTRALIA. Government Printer, Adelaide.

_____, Glover, C.J.M. and Southcott, R.V., 1974: THE MARINE AND FRESHWATER FISHES OF SOUTH AUSTRALIA. Government Printer, Adelaide.

Simpson, G.G. and Roe, A., 1939: QUANTITATIVE ZOOLOGY: NUMERICAL CONCEPTS AND METHODS IN THE STUDY OF RECENT AND FOSSIL ANIMALS. McGraw Hill, New York.

Smith, J.L.B., 1970: THE SEA FISHES OF SOUTH AFRICA. 5th ed. (1965), 2nd impression (1970). Central News Agency, Cape Town.

Strasburg, D.W., 1964: Further notes on the identification and biology of echeneid fishes. *Pac. Sci.*, 18(1): 54-57.

Waite, E.R., 1894: New or rare fishes from Maroubra, New South Wales. *Proc. Linn. Soc. N.S.W.*, second series, 9(2): 215-227, pl. 17.

_____, 1899: Scientific results of the trawling expedition of H.M.C.S. 'Thetis', introduction and fishes. *Aust. Mus. Mem.*, 4: 1-132, pls 1-30, text figs 1-10.

_____, 1904a: Additions to the fish fauna of Lord Howe Island, No. 4. *Rec. Aust. Mus.*, 5(3): 135-186.

_____, 1904b: Catalogue of the fishes of Lord Howe Island. *Rec. Aust. Mus.*, 5(3): 187-230.

_____, 1916: Fishes of the Australasian Antarctic Expedition, science reports, series C, 3(1). *Aust. Antarctic Exped.*, (c), 3(1): 5-82, pls 1-5, text figs 1-16, 2 maps.

_____, 1921: Illustrated catalogue of the fishes of South Australia. *Rec. S. Aust. Mus.*, 2(1): 1-208, pl. 1, 293 text figs.

_____ and Hale, H.M., 1921: Review of the lophobranchiate fishes of South Australia. *Rec. S. Aust. Mus.*, 1(4): 293-324, figs 39-56.

Whitley, G.P., 1927: Studies in ichthyology. No.1. *Rec. Aust. Mus.*, 15(8): 289-304, pls 24, 25, text fig. 1.

_____, 1945: New sharks and fishes from Western Australia. Part 2. *Aust. Zool.*, 11(1): 1-42, pl. 1, text figs 1-15.

_____, 1962: MARINE FISHES OF AUSTRALIA. 2 vols. Jacaranda Press, Brisbane.

_____, 1964: Name-list of the fishes recorded from Australia. Presidential address, appendix B. *Proc. Linn. Soc. N.S.W.*, 89(1): 31-60 (list), 11-127 (address).

Whitley, G.P., 1968: A check-list of the fishes recorded from the New Zealand region. *Aust. Zool.*, 15(1): 1-102, figs 1,2.

Woods, P. and Sonoda, P.M., 1973: Diretmidae. In FISHES OF THE WESTERN NORTH ATLANTIC. *Mem. Sears Found. Mar. Res.*, 1(6): 290-296, figs 12, 13.

Papers and Proceedings of the Royal Society of Tasmania, Volume 113, 1979.

(ms. received 9.8.1978)

SKELETAL REMAINS AT CONINGHAM, TASMANIA, AUSTRALIA

by Alan Wallace and Jim Stockton
University of Tasmania and National Parks and Wildlife Service, Tasmania

(with one table and four plates)

ABSTRACT

WALLACE, A. and STOCKTON, J., 1979 (20 vii): Skeletal remains at Coningham, Tasmania, Australia. *Pap. Proc. R. Soc. Tasm.*, 113: 149-153 (incl. four plates). ISSN 0080-4703. Department of Anatomy, University of Tasmania, Hobart, Tasmania and National Parks and Wildlife Service, Magnet Court, Sandy Bay, Tasmania, Australia.

Human bones, including a well-preserved skull, have been excavated from an Aboriginal midden exposed by erosion at Coningham, Tasmania in 1976. Associated charcoal has been C14 dated 840 ± 95 years BP.

INTRODUCTION

In February 1976 an alert holidaymaker observed human bones eroding from a bank at Coningham, a sandy cove 25 km south of Hobart. The bank is one metre high, immediately above the high-water mark and represents the seaward edge of open dry eucalypt forest sloping steeply to the foreshore. An area of fairly level ground at the site had been used for keeping a small boat, and such usage had possibly destabilised the earth. Following the collection of exposed bones, work was halted, and the site later carefully excavated by one of us (J.S.).

SITE DESCRIPTION

The site was of shell midden covered by grass (Tasmanian Aboriginal Sites Index Card 126). It was divided into arbitrary 1 metre-square grid units, and attempts were made during excavation to follow the depositional stratigraphy. This proved impracticable and was discontinued. The site was then excavated in arbitrary spits. Finds were pedestalled and plotted before removal, but the skeletal material had an oddly confused distribution. A charcoal sample was collected from amongst the bones and submitted for radiocarbon analysis (SUA-626). This yielded a date of 840 ± 95 years BP.

The main shell present in the midden was *Ostrea angasi* (mud-oyster) and lesser amounts of *Mytilus planulatus* (mussel). Individuals of the scallop family *Pecten meridionalis* were also found in the deposit. These have been rare in other sites examined in the D'Entrecasteaux Channel area. One *Ostrea* shell had a central hole in it, but this may have been due to natural causes.

At the horizon of densest bone concentration two arcs of *Ostrea angasi* shells were standing on edge. This was unusual as most of these large shells lay flat in the deposit. No implements or ochre were recovered from the site.

The occupation sequence for the site appears to have started after the Holocene sea-level rise, but as no bottom radiocarbon date has been made on the deposit, it is impossible to give an accurate indication of the basal date. At first a typical low energy system marine midden accumulated on the bank above the beach. Then an unburnt body, still more or less intact, was left on the site of the midden. There is no conclusive sign of burning of the bones or of a hearth associated with the bones. Similarly, there is no sign of a pit having been dug into the deposit into which a

fig 1

fig 2

fig 3

fig 4

body or bones were placed. The corpse was then probably disturbed by carnivores, leading to a breaking up of long bones and a rearrangement of bone fragments. The bones were then gradually covered by aeolian sand blowing up from the beach. Such a process still continues and the soil level is aggrading.

In recent years the sea has begun to erode the bank on which the midden and skeletal material rests. Part of the skull eroded out, and its recognition led to the salvage excavation of the remaining material.

GENERAL DESCRIPTION OF SKELETAL REMAINS

The bones have been acceded to the Tasmanian Museum and Art Gallery as M4301. The skull was largely intact, with the exception of the facial skeleton which was fragmented and incomplete. Much reconstruction of the left orbital margin has been possible, together with the anterior maxillary region, including part of the nasal area.

Measurements are given in Table 1, and Plates 1 to 4 depict the skull in normae frontalis, verticalis, occipitalis and lateralis. The shape of skull is sphenoid and phaenozygous in normae verticalis. Prominent superciliary ridges are present with a moderately marked (Broca grade III) glabella. There is a supraglabellar fossa extending laterally into a shallow ophrionic groove. Zygomatic trigones are prominent and there is moderate post-orbital constriction. Temporal crests are sharp anteriorly, but fade away posteriorly. The forehead is sloping (frontal curvature index 21) and the vault of the skull is keel-shaped, particularly along a median parietal ridge running back from bregma. The sagittal suture does not lie in a groove, and the parietal bones slope straight out to moderate parietal bossing. Very marked supramastoid crests are present, whilst the mastoid processes themselves are of medium size. The orbits are rectangular and set somewhat obliquely. Considerable sutural obliteration on the vault of the skull suggests an age of death of 30 to 40 years. The spheno-occipital junction is not fully ossified, which would have indicated a much younger age, but the bone in this region is damaged and such interpretation dubious.

The maxilla and palate are incomplete and several teeth have been lost post-mortem; those remaining comprise all four upper premolars and the anterior two molars on each side (M^1 M^2). In the mandible only part of the first right premolar and the anterior two left molars were retrieved. There is a congenital absence of the third lower left molar (confirmed by X-ray). All the teeth are very heavily worn. There is moderate interproximal attrition and some possible evidence of chronic peridontal disease but no evidence of caries.

The skull was sexed using Larnach and Freedman's (1964) system for sexing Aborigines from Coastal New South Wales by seven characteristics.
Values are as follows:

Feature	Points
Glabella	1
Superciliary ridges	3
Zygomatic trigone	3
Malar tuberosity	3
Mastoid process	2
Occipital markings	2
Palate size	Unavailable and therefore given a mean score of 2
Total	16

The total of 16 points designates a male.

The right tibia lay in two fragments. When reconstructed it was 0.35m in length. A hundred millimetres from its proximal end, and on the postero-medial surface a flake of bone is missing about $3cm^2$ in area and with a maximal depth of 1mm. The deficiency is wedge-shaped, with a shallow lower section deepening to an abrupt upper border. There is no periosteal reaction and the bone is uniformly weathered. It is difficult to see how this damage could have been caused by any stone implement. It has more the appearance of being the work of a steel blade at or after death!

Using Pearson's modified table (after Olivier) for estimating stature from male tibiae, an estimate of a height of 1.62m is reached.

Other post-cranial skeletal remnants comprise the shaft of the right femur and fragments of vertebrae, ulna bones, patellae and ribs. Much of the shaft of the right humerus is also preserved. There are fragments of both hips, each showing sufficient of the sciatic notch to indicate its curvature and confirm masculinity. There is also a portion of a scaralised fifth lumbar vertebra.

The bones appear Aboriginal and fit into the accepted range of Tasmanian skeletons yet do not show any of the features that have been classically associated with Tasmanians (Wallace and Doran 1976). The presence of damage to the tibia seemingly due to a steel blade is clearly an anachronism if the archaeological context is accepted and a date of 840 years BP. attributed. A possible explanation is that at some point in the last century the area has been partly dug and something like a spade or adze has sliced into the buried bone. The alternative is of course that the bones date to the post-contact period and represent an intrusion into the (dated) charcoal of the midden. Collagen dating of the bones is planned to clarify the problem.

TABLE 1

CRANIAL MEASUREMENTS AND INDICES

Measurement	Value in mm	Measurement	Value in mm
Maximal cranial length	188	Orbital height	30
Maximal cranial breadth	145	Orbital breadth	40
Basi-bregmatic height	135	Post-orbital constriction	19
Basi-nasal length	100	Frontal subtense	25
Upper facial height	64	Frontal chord	119
Basi-alveolar length	99	Frontal curvature index	21
Nasal height (estimated)	50	Cranial index	77 (mesocranial)
Nasal breadth	28		
Supra-orbital breadth	105	Orbital index	75
Minimal frontal breadth (at fronto-sphenoid suture)	86	Cranial capacity (von Bonin formula)	1373
		Cranial capacity direct measurement	1250

REFERENCES

Larnach, S.L. and Freedman, L., 1964: Sex determinations of Aboriginal crania from coastal New South Wales, Australia. *Rec. Aust. Mus.*, 26(11): 295-308.

Wallace, A.G. and Doran, G., 1976: Early Man in Tasmania - new skeletal evidence. In Kirk, R.L. and Thorne, A.G. (Eds): THE ORIGINS OF THE AUSTRALIANS. Aust. Inst. of Aboriginal Stud., 173-182.

Papers and Proceedings of the Royal Society of Tasmania, Volume 113, 1979.

(ms. received 2.10.1978)

"FEMALE SETTLER MARTHA HAYES" 1786-1871

by Frank Bolt
Kingston Beach

(with one table)

ABSTRACT

BOLT, F., 1979 (20 vii): "Female settler Martha Hayes" 1786-1871. *Pap. Proc. R. Soc. Tasm.*, 113: 155-167. ISSN 0080-4703. 39 Kingston Heights, Kingston Beach, Tasmania, Australia.

Martha Hayes (1786-1871) came to Australia in 1803 as the daughter of a female convict. She formed a liaison with Lt. John Bowen and had two daughters by him. Later she married Hobart settler Andrew Whitehead and, after his death, police clerk Barnard Williamson.

Martha lived in Hobart Town from 1804 onward, and her life is closely interwoven with many colourful characters who lived in Hobart during the first few decades.

INTRODUCTION

During a recent professional project I kept coming across the name of Martha Hayes, a girl to whom various things were attributed depending on what popular press article one read. Responsible information however was hard to come by, and in the end I decided to satisfy my curiosity - hence this paper.

Martha turned out to be a girl from London whose mother was transported to Sydney as a convict in 1803 on the "Glatton". In all probability, Martha came out with her mother (as did several other children of transported female convicts), and while on board became acquainted with a young naval lieutenant John Bowen, who soon after arrival in Sydney received a commission from Governor King to establish a settlement at Risdon Cove in Van Diemens Land. After Bowen's return to England Martha eventually married ex-convict Andrew Whitehead, and her subsequent life and environment appeared to be worth recording as they throw an interesting light on the life of some of the early settlers of Hobart Town.

The elucidation of her early life was not without its complications; proof of her existence before May 1803 is not available, and I have had to assume that she came out with her convict-mother on the "Glatton", and on it met John Bowen. The likelihood of this assumption being correct is many times that of any other version, and I can only leave it at that until other evidence turns up.

Similarly, there is the intriguing question of who travelled from Port Phillip to Port Jackson to inquire about Martha's mother, by then serving her time in Sydney. What was recorded as intended to happen and what actually did happen may be two different things, and on balance I favour the version that it was Thomas Hayes who went to Sydney, especially as he is mentioned by name in a dispatch from Governor King to Collins.

The details of Martha's later life are followed much more readily as a result of the facts and clues contained in Knopwood's recently published diary, and full credit must be given here to this magnificent effort by Mary Nicholls. Without her

painstaking transcription of the old gossip's notes and comments a paper such as this would not have been possible.

The story is not complete; interesting gaps remain, and I hope that it may induce those who are in the possession of related documents or family papers or other articles to come forward, thus adding further detail to this picture of some of Hobart's early settlers.

One final point that struck me very much during the compilation of Martha's story is this: although the society of her days was very stratified, it is amazing to see how all these people intermingle, know each other, and together make the best of a potentially (and often actually) disastrous situation. I am convinced that in those days the foundations were laid of a new social structure to fit a new country, a structure that is still clearly recognisable today.

I like to express my thanks to several descendants of the Hayes families, to Geoffrey Stilwell of the State Library of Tasmania, the staff of the Archives Office of Tasmania, Mrs. M.J. Tipping of Melbourne, and to the staff of the various libraries in Sydney and Melbourne as well as a number of others who were not afraid of discussing skeletons in the cupboard. Fortunately, these matters are no longer quite as emotional as they used to be.

THE 'PRIVATE CONCERNS'

Early in 1801 a Henry and Mary Maria Hayes were arrested in London on suspicion of having received stolen goods: a trunk and other valuables worth about £1000.[1]

They were committed to the Newgate Prison by a Mr. Bond on May 15, 1801, and were then described as follows: Henry Hayes, a calico-glazier, from Tetbury (a small village in the Cotswolds), Gloucestershire, age 39, height 5'7", brown hair and with a dark complexion. His wife Mary came from London, was 35 years old, height 5'4", had grey eyes, brown hair and also had a dark complexion.[2] The charge was that they had received goods which had been stolen by a Thomas Collett, alias 'Putty'. The case was tried by Judge Grose who found Henry not guilty. Mary however was sentenced to fourteen years transportation[3], and left for Port Jackson on the "Glatton" in January 1803, the ship on which a John Bowen served as a naval lieutenant.

Henry and Mary had a daughter Martha (see genealogical table) and it must be assumed that this daughter accompanied her mother on the "Glatton" in the same way as several other female convicts on board this ship had some or all of their children with them. At the time Martha was sixteen years old and at that age she would have been classified as a free passenger. So far, no confirmed passenger list of the "Glatton" has been found.[4]

Once on board the "Glatton" it would not have been long before Martha and John Bowen met; an attachment between the two developed, and soon after the arrival in Sydney Martha commenced to live with Bowen.[5] Her mother in the meantime had been handed over to the authorities in Sydney, and nothing is known of her circumstances in Sydney after she left the "Glatton".[6]

Bowen arrived at a time when Governor King was in need of a suitable officer to take charge of a proposed settlement on the Derwent in Van Diemen's Land. Bowen was ambitious, offered his services and was accepted. To assist him, he persuaded several of his acquaintances from the "Glatton" to join him, and after a number of false starts they eventually arrived in Risdon Cove.[7] The actual unloading of the ships began the day after their arrival, i.e. Monday September 12th, 1803, and Martha, who had joined Bowen on this expedition, prided herself for the rest of her life on the fact that she

had been the first white woman to set foot in Van Diemen's Land, having been carried ashore by Bowen's men.[8] The settlement at Risdon Cove was named Hobart (after the Secretary of the Colonies of those days, Lord Hobart), and consisted of a collection of about three dozen simple huts or tents. To the girl fresh from London the new colonial life must have seemed very primitive indeed.

In the meantime, Henry Hayes had decided to follow his wife and daughter, and when Lord Hobart advertised for volunteer settlers for a new settlement in Port Phillip,[9] Henry was among those whose application was accepted. A list by Under-Secretary John Sullivan to Governor King described Henry as a carpenter aged 35, and noted that he had received 'very favourable testimonies' about Henry Hayes from a J. Savage of Sherrard Street and a J. Lambert of Titchborn Street, London.[10] On the same list of accepted settlers is also mentioned a Thomas Hayes, a millwright, with a wife and two children. Although Henry and Thomas will have known each other very well from 1803 onward, no reference has been found which definitely establishes a family relationship between them.[11] The name Hayes occurs very frequently indeed on the lists of early arrivals in Australia, both as free settlers and as convicts.

The settlers left Yarmouth on the "Ocean" in April 1803 in company of the convict transport "Calcutta". This convoy was being sent by the British Government to establish a new settlement in Port Phillip, thus claiming that part of New Holland. The expedition was under the command of Lt. Governor David Collins, who had a number of senior civil and military officers with him to assist him in his task, one of them being a chaplain, the Rev. Robert Knopwood.

Very little is known about Henry, so that one gets the impression that he was a somewhat shy and perhaps a withdrawn person who never drew any attention, and it is also known that he was the only settler who could not write his name.[12] Matthew Bowden in his 'Journal of the outward Journey' described him as a carpenter with a wife who was a convict in Port Jackson.

Early in October 1803 the convoy arrived in Port Phillip where, due to the very difficult conditions on shore, most of the settlers had to remain on board for the time being. The captain of the "Ocean", however, wanted to take his ship to China for trading purposes, and for this reason his passengers and cargo were a few days later transferred to the "Calcutta", these passengers including Thomas Hayes and his family. The "Ocean" then left, but when it dropped in at Port Jackson Gov. King chartered the ship again for government purposes and sent it back to assist Collins, who by that time was known to have second thoughts about Port Phillip as a suitable place to settle. Collins had indeed decided to cut his losses and was considering a new location either at Port Dalrymple at the mouth of the Tamar or at the Derwent in southern Tasmania. For this reason he sent the "Lady Nelson" to survey the entrance to the Tamar and its environment, and while awaiting her return Collins offered his settlers a choice: stay with me come-what-may or sail in the "Calcutta" to Port Jackson. Nearly all indicated that they wished to stay with him, but the settlers leaving with the "Calcutta" included Thomas Hayes and his family.[13]

We cannot be sure about the motivation of this decision by Thomas Hayes. On the face of it he chose the comparative security of Sydney rather than the unknowns of a second attempt in Tasmania. In view of his early return to Collins, however, a more likely explanation is that he used the opportunity to visit Sydney for the purpose of making inquiries about convict woman Mary Hayes on behalf of Henry Hayes, who either lacked the opportunity or the courage to do so himself.

As it was, events turned out to be extremely fortunate for Henry and his Mary. Shortly after the arrival of the "Calcutta" in Sydney, John Bowen the Commandant of the small settlement at Risdon Cove on the Derwent turned up in port with a few mutinous

soldiers in order to bring them to trial.[14] Governor King was furious with Bowen for absenting himself from his post at the Derwent just when at any minute a major French expedition might sail up the river, and promptly sent him back in the "Integrity" with instructions to hand over his command to Collins should the latter indeed turn up.

This departure of a ship which was to meet Collins' party gave Thomas Hayes a golden opportunity to request Gov. King permission to join Collins after all, and to take Mary Haye's with him. King gave his permission[15], and when Bowen and his party eventually turned up in the Derwent (missing the foundation of Hobart by a few days), he had not only settler Thomas Hayes and his family with him, but also Martha's mother Mary Hayes.[16]

And so, after three years of separation and adventure, the Hayes family was together again.

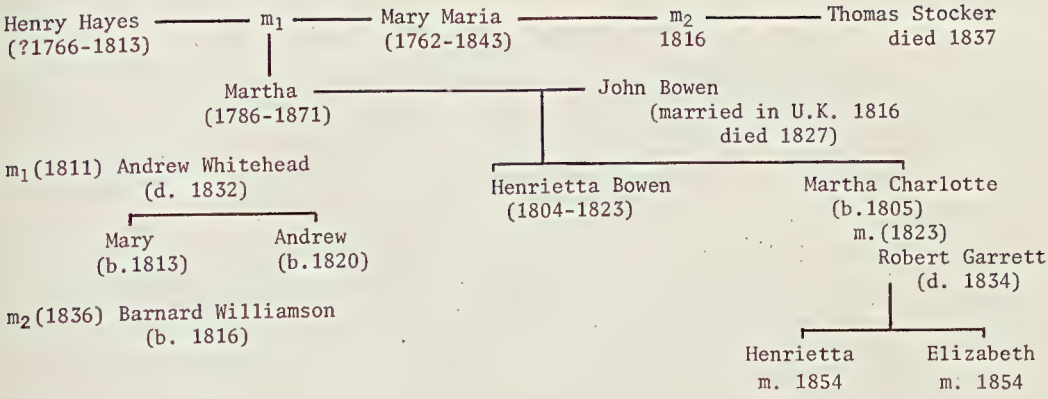
A few days prior to Bowen's return, the settlers who had come with Collins had been taken 'further up the river'[17] to the muddy shores of what is now New Town Bay, near the present site of the Queens Walk Recreation ground just below "Runnymede". There they were dumped ashore, and although Collins and Knopwood visited that same day the Risdon Cove settlement just across the river, the event did not even draw a mention in Knopwood's diary. (Probable reason: Collins had misgivings about the settler's choice of New Town Bay[18] and wanted to demonstrate that he washed his hands of their choice). The settlers however were in no mood to go through the Port Phillip experience of dry sand and lack of water again, did what they thought was right, and went for the rich and moist soil inland from New Town Bay.[19] They suffered much hardship as they huddled in makeshift tents and even hollow trees on the banks of the New Town Rivulet while surveyors hacked their way through dense virgin forests to survey the 100-acres allotments which had been promised to the settlers before they left England nearly a year before.[20] Eventually, the land allotted to Henry Hayes stretched between the present New Town High School and Pedder Street. Thomas Hayes became his neighbour on the east, their common boundary being what is now Montagu Street. The next strip of land was occupied by Thomas Issell, while the stretch of land between his eastern boundary and the beach at Cornelian Bay became the Government farm,[20] of which ex-convict Andrew Whitehead would become the manager within a few years.

Henry called his property 'Henrietta Farm', and his house probably stood on the very spot where today the New Town High School stands; the house soon became known as a place where visitors were always welcome, Knopwood often being among them and Martha spent much time on the farm after Bowen left her in 1804. There also was very much contact between the settlers as a group; and it was not long before she took her place among them as their equal.

While Bowen remained in charge of the settlement at Risdon Cove, Martha continued to live with him and will have witnessed his trials and tribulations as Commandant of the first settlement in Tasmania: the laziness, insubordination and mutiny of his soldiers and officers, and later the affray with the natives.

In March 1804 Knopwood stayed for a few days with Bowen (probably at the request of Collins, to keep an eye on what was going on) and noted one day in his diary: "... this morning Gov. Bowen's young friend was confined to her bed". So was noted the birth of Henrietta Bowen, the first European person to be born in Tasmania.[21] About this time Bowen's relationships with Gov. King and Collins became embarrassing as he kept on postponing his proposed return to England. Bowen obviously did not wish to leave Tasmania before having 'settled his private concerns' as King noted several times:[22] providing as well as he could for Martha and their daughter Henrietta. In the end, however, he could not delay his departure any longer, and arranged to return to Sydney in the "Ocean" which was to leave Hobart in about July.

GENEALOGICAL TABLE



Of major advantage to Martha was Bowen's action in arranging for Collins to declare her a settler.[23] This gave her the right to receive government rations over the next few years, a grant of land (although she only got half the usual 100 acres), convict servants to clear and work the land and some seed and live stock to get the farm going. Later surveys however showed the area of her grant to be more like 65 acres, while Martha also turned out to be a clever manager: her farm prospered and in later years became a worthwhile asset, as the returns of statistical surveys of those days show. The location of the grant covered the area of what is now the eastern end of Lampton Avenue, and it is likely that this street started its existence as a track over her farm with paddocks and wheatfields on either side.

Shortly before his departure in August 1804, Bowen also built Martha a 'house', probably a simple timber hut, and this was the place where he spent his last few days in Van Diemen's Land with his Martha.[24] It was to this 'house' during these last few days that he invited some of his closer friends for a last meal: Knopwood, Wilson etc. But then the final embarkation orders are given: Bowen and Martha part, and on his last night in Hobart on board of the 'Ocean' he said goodbye to Knopwood, who especially came aboard to farewell his friend. Early the next morning the 'Ocean' left Sullivans Cove, and Bowen never saw Van Diemen's Land or Martha again.

As noted earlier, Bowen before his departure had gone to some considerable length to provide for Martha and Henrietta. Apart from the arrangements with Collins to have Martha declared a 'female settler' which gave her considerable advantages, Bowen also got Knopwood to take a special interest in the well-being of Martha and her daughter (a task which he performed well for many years after), whilst on his return to Sydney Bowen made arrangements to have pigs, wheat and maize sent to her.[25]

Collins became godfather to one of the children, and Bowen himself seems to have sent gifts from England on appropriate occasions.[26] At the time of Bowen's death the 'Tasmanian' of 14.3.1828 noted that 'his daughter, Mrs. Dr. Garrett from Pittwater (Sorell) had been well provided for'. In later years Bowen tried several times to return to Tasmania, but only on his own terms. When the news of the death of Collins became known in London Bowen offered his services to Robert Peel but was rejected,[27] ostensibly on a technicality. His services were rejected again in 1819 when he offered to join Commissioner Bigge as an expert on the situation in Van Diemen's Land in which, he reminded Under-Secretary Goulburn, he had established the first settlement.[28]

Bowen married in 1816, but died without any further children in 1827 'after a long and painful illness'.

THE 'TEDIOUS COURTSHIPS'

Soon after the departure of Bowen, Martha realised that she was expecting Bowen's second child, and after some initial hesitation she and her mother decided to visit Knopwood in his tent on the shore of Sullivans Cove.[29]

Knopwood promised his help, and to underscore his promise he visited the Hayes family several times during the coming summer, and recorded in April 1805 the birth of Martha Charlotte. After the birth Knopwood continued to visit the Hayes family, but at the end of that month he entered a curious event in his diary: "At half past eleven I met the Lt. Gov. and Mrs. Powers (Collins' mistress). She told me that they were coming to my house to speak to me. The Governor said that he could not make it convenient to go to the farm and have Martha Hayes' children xtiand. I asked him if he did not mean to stand for the child. His answer was 'no', but requested that I would go there. I walked and of course found them unprepared with godfather and godmother as the Lt. Gov. and Mrs. Powers had promised to stand for the child".

The next day, Martha and her mother went to see Knopwood to discuss the situation. Obviously, Mrs. Powers had persuaded Collins not to fulfil the promise which he apparently had made at some time in the past, and Knopwood probably advised Martha to let the matter rest for a while. His advice was right, because after some months Collins changed his mind; Knopwood then baptised both children while the Governor 'stood for one' (probably Martha Charlotte).[31] 30

Later that year Martha's father Henry was visited by Joseph Holt, a visitor to Hobart who had been asked by Collins to give him his opinion on the skill and efficiency with which the new farmer-settlers along the shores of the Derwent went about their job (reply: not very well). Henry and his wife Mary were then living in their small farm cottage along the New Town Creek, while Martha also happened to be there at that occasion. Henry and his wife were found to be making a living from 'pleating straw for the ladies', and were augmenting their income by raising dogs, selling the young pups for ten pounds each (a very considerable sum in those days). It was at this occasion that Holt made his wellknown tribute to Martha: '... the daughter was a beautiful girl; she was the prettiest violet I saw growing on the Derwent'. He also summed up Martha's mother very quickly: '... the old lady (she was in fact then only 44!) was very pleasant, as my friend and I carried a bottle of good rum with us...'[32].

During the years after Bowen's departure, Martha's farm on the shores of the Prince-of-Wales Bay began to improve steadily. When Bowen left she started her farm with eight sheep and two goats. Two years later she had two acres under cultivation, and ran two cows, 35 sheep and 14 goats.[33] A year later still in 1807 she had managed to increase her acreage to five. She then had still only two cows and only 11 goats, but her flock of sheep had grown to 40; at that time she was also responsible for two convicts, very likely working for her as labourers on the farm. In 1809 there were seven acres cleared and under cultivation on which she ran three cattle, 70 sheep and seven goats.[34] It is clear from this that she not only managed quite well as 'a female settler' but that she also was in a privileged position during the terrible hunger winters which occurred during the first few years of the settlement, when food was very scarce indeed. The surrounding settlers liked her and considered her as an equal. When for instance a proper bridge across the New Town Creek became desirable (possibly the one which used to be at the lower end of Bay Road), she joined others at a public meeting of the settlers and put her signature under an agreement to fund the cost of the bridge with those of the others.[35] Later she and her mother appear to be

the 'executrixes' of the will of Thomas Preston, a neighbouring settler who died after a fall from his horse.[36]

From all accounts therefore she not only was an attractive woman but also one who had shown herself to be a clever manager of her affairs, and it was thus no wonder that she soon began to attract the attention of one of her neighbours, Andrew Whitehead, a convict who had come out with Collins in 1803, and who was eighteen years her senior. He had turned out to be a good farmer, and after receiving an absolute remission of his sentence[37] Collins appointed him in charge of the somewhat neglected Government farm at Cornelian Bay, which covered the present-day sportsfield and cemetery in that area.[37]

In 1811 the two were married by Knopwood, and from then on Whitehead managed the two farms together with the cattle owned by Martha's two daughters, who had adopted the name "Bowen" as their surname.[38] Encouraged and aided by their grandfather Henry Hayes (who had even named his own farm 'Henrietta Farm' after the eldest girl) they seem to have owned a fair amount of stock, and even as teenage girls are frequently listed as the suppliers of fresh meat to the government store in Hobart. Soon their interests diversified further, and together with their grand(step) father T.W. Stocker they obtained interests in the Ross area and provided some or all of the funds for the building of the first 'Man-of'Ross' Hotel in the centre of that town.[38]

In 1813 Macquarie granted the land covered by the government farm at Cornelian Bay to Whitehead, and at that time life must have looked decidedly good to Andrew and Martha. Earlier that year a daughter Mary had been born to them; Martha still had the farm at the Prince-of-Wales Bay, and in general enjoyed her social position within the New Town society. Knopwood was a frequent guest as were several of the military officers from Hobart Town, and even Gov. Macquarie from Sydney visited their farmstead and was moved to describe Whitehead as 'a respectable farmer'.[39] It must be stressed however that Whitehead and his household were an exception. Oxley confirmed the earlier opinion of Holt in 1805[32] when he reported in 1810[41]: '... few of them originally were farmers or understand anything about agriculture; they have in consequence so exhausted their ground by repeated crops of the same grain that it now produces little or nothing'. Excluding Pitt, all the original settlers along the New Town Creek sold or lost their grant within the next decade or so, and the fine homes that can still be found along this creek were built by the second or third generation of owners, people who knew what land ownership was all about.

An interesting sidelight on their life is that it was probably on Whitehead's land that surveyor James Meehan in the winter of 1813 recorded the presence of a race track - the earliest known reference to the racing sport in Tasmania. The exact location of their farmstead is not known at present; a likely spot however may be indicated by the old foundations in the garden of the house of the caretaker of the Cornelian Bay cemetery.[40]

Unfortunately the good times in the Whitehead household were not to last. In 1814, 2800 gallons of liquor (about two gallons per head of population; a colossal quantity for that time) was smuggled ashore from the 'Argo', Whitehead and a celebrated ex-convict Dennis McCarty being heavily involved in the actual operation. The barrels were very likely landed on the beach of Cornelian Bay, and then stored in the nearby farm (Whitehead's) for further distribution in thirsty Hobart Town.[42] But someone talked, and Gov. Davey, although he himself was very likely one of the waiting customers, was forced to send an officer from Government House to confiscate the lot.

The seizure caused great consternation within the Hobart community, and it is amusing to follow in Knopwood's diary the hurried consultations that took place. Soon the plan is ready: everyone professes not to know the regulations relating to the

disposal of 'the spirits' (permission should have been obtained first from Macquarie who complained later that even in Sydney officers from the highest rank did not have so much liquor on their hands for private consumption as some of the Hobart convicts, and he mentioned two by name),[43] and a formal auction was arranged. For some officially unexplained reason Edward Lord (a former Commandant of Hobart) was able to buy most or all of the stock,[44] and the sigh of relief throughout Hobart Town was very audible indeed. The evening after the auction a party was held at Knopwood's house at Battery Point, the guests including Whitehead, McCarty and Captain Carr, and the main topic of conversation does not need to be guessed at.[45]

The sequel to the story became a comedy. Davey had to punish somebody, so he sentenced Whitehead to house arrest, McCarty, to a prison sentence, a sentence which was to be spent in Sydney - apparently Davey could not under the circumstances visualise an effective imprisonment of McCarty in Hobart Town. It took a greatly bewildered Macquarie only one drink with McCarty to find out what really happened before realising that he was beaten. Nevertheless he was furious, and let Davey know so in no uncertain terms: '... I think that Whitehead was even more guilty than McCarty; the spirits were (after all) seized in Whitehead's house'. McCarty however got fed up with being the lone scapegoat in the whole affair, and when he began to threaten to sue Davey for wrongful arrest, trespassing and stealing, Macquarie thought the better of it and remitted the remainder of McCarty's sentence. Using his newly purchased schooner 'Geordy', McCarty promptly returned to Hobart, where his unexpected re-appearance on the wharf was a good-enough excuse for a welcome-home party at the Whiteheads. The next day Davey released Whitehead from his house arrest.[45]

In this environment the two Bowen girls continued to grow up and gradually began to take part in the social life of Hobart Town. They visited Knopwood from time to time, and busied themselves looking after him during his frequent bouts of illness. Always together, they also made it an annual ritual to visit him when the fruit in his garden was ripe, while their grandmother made sure that the raspberries from his garden were made into a delicious jam.[46]

During these eventful but still happy years Knopwood remained a regular guest at the farm. He usually walked to New Town after the church service in a barn or in the open air at Hobart Town (which at that time was still without a proper church building), and then would have dinner with the Whiteheads. He also regularly dropped in once or twice during the week, and especially Andrew, one of the family, returned these visits almost every week by calling on Knopwood. They would then 'have a pipe', a drink and a meal, and often enjoyed the company of other friends of Knopwood, usually military officers or visitors from ships in port. This lifestyle continued till late in 1817 when Whitehead sold his farm at Cornelian Bay and moved to Herdsmans Cove near Bridgewater.[47]

Martha also disposed of her farm about that time, and in spring 1817 Knopwood dined for the last time with the Whiteheads in the homestead near the beach where he so often had spent so many happy hours. Only one year ago he himself had had to dispose of his own cottage on the waterfront of Sullivans Cove, and quite clearly the small world of Hobart Town was not going to be the same for them any more.[48]

The change from Cornelian Bay to the house near the shore of Herdsmans Cove caused many problems for the Whiteheads. For Andrew there were financial problems and farming problems: during one cold night in October he lost 50 sheep, an experience which apparently was new to the settlers.[49] For Martha it meant not having the two Bowen girls around the house any more. Their education made it necessary for them to be in town, and arrangements were made for them to live with their grandmother Mary[5], who soon after the death of her husband Henry in 1813 had begun a new life as the owner of the Derwent Hotel in Elizabeth Street, behind the present G.P.O.[50].

One gets the impression that grandma Hayes thought it about time that the girls received 'a broader outlook', and she seems to have done the job with gusto. She gave the girls some kind of a 'coming-out' party[51] and also made sure that they were seen in the right places at the right time.[52] In between all this, grandma Hayes did not forget her own interest. One of the notable customers in her hotel was Thomas W. Stocker, a well-known settler with a good eye for business (farming, coach transport between Hobart and Launceston, hotels, real estate etc.). Soon the two came to an understanding, and in 1816 Knopwood became the celebrant of their marriage. Noticed the "Hobart Town Gazette" of the day (somewhat tongue-in-cheek): '... was married, by the Rev. R. Knopwood, at the Derwent Hotel, Thomas Stocker to Maria Hayes, Widow, of the Derwent Hotel, Elizabeth Street; after a long and tedious courtship of *two* years'.[53]

The finer points of the joke are no longer known, but the word 'tedious' and the underlining of the word "two" stimulate the imagination. However, a great time was had by all and sundry during the wedding festivities, including the pickpocket who relieved Stocker of his silver-and-gold watch during the merrymaking![53]

Beginning with the move to Herdsmans Cove we seem to notice a gradual change in the position if not the fortune of Whitehead. He still kept on delivering large quantities of meat to the government stores in Hobart, but in May 1818 he apparently was forced to advertise a request 'that all Persons who stand indebted to him will pay the amounts of their respective Debts', as he in turn is also being called upon by his creditors to 'liquidate several claims'.[54] Presumably his financial embarrassment passed, as he kept on selling large quantities of meat to the government stores.

Andrew and Martha had a second child Andrew in 1820. Little is known about their circumstances during that period, but they still seem to be doing reasonably well. Andrew for a while held a licence for his house at the Cove[55], and in 1819 even the Governor in the company of Knopwood stayed at the farm[56]. It is however the very last time that Knopwood does so, and one begins to wonder what has happened.

An interesting note on the social standing of the Whiteheads at that time can be found in a letter from Gov. Sorell to Commissioner Bigge in which he explains the basis of the allocation of seats in the newly built St. Davids Church: '... relative to rank and person'. Military officers occupied the front row, followed by Civil Officers, important merchants, settlers and servants, with the convicts having to make the best of the situation in the rear of the building. In this pecking order, the Whitehead and the Stocker households shared the sixth out of eleven rows.[57]

Notwithstanding the change in relationship between Knopwood and Andrew Whitehead, the Bowen girls still kept visiting the ageing chaplain, while Martha also accompanied them occasionally, especially in summertime and on the all-too-frequent occasions when Knopwood was ill. Knopwood still enjoyed the company of Martha very much, and at one stage even went to visit her when she stayed with her mother at the Derwent Hotel.[58] No doubt the bonds of the past were still present, and this became very clear when Henrietta Bowen (the eldest) became seriously ill and died (June 1823). Knopwood stayed with her during her last hours, and after her death described her as 'one of the finest girls on earth'. He later tells us that her funeral '... was attended by the first people of distinction'.[59] Henrietta was buried in St. David's Cemetery, and from an inscription on her tomb it appears that it was erected by her grandmother, Mary Maria Stocker.[60]

Early in 1822 arrived in Hobart Town, via India, a Dr. Robert Garrett, 24, a settler from Wigtownshire in Scotland, who sought to establish himself in the colonies as 'a surgeon'.[61] He seems to have been a pleasant and gregarious young man who not only managed to get himself appointed as a district doctor in Sorell, but who also became a member of Knopwood's circle of friends. Knopwood in those days was not very

well, and Garrett became his personal physician. As such, it was not long before he met the Bowen girls, and together they spent many hours nursing either Knopwood himself or his ward Elizabeth Mack back to health again.

Robert and Charlotte fell in love, and in December 1823 they were married in St. Davids Church - the wedding ceremony not being performed by Knopwood but by the Rev. Bedford, probably because it was no longer Knopwood's parish. The notice in the "Hobart Town Gazette" is not long, but it does mention the fact that the bride was the daughter of Capt. John Bowen.[62]

Although Martha during this time remained in the background she was still very much there. It was she who made sure that Knopwood was being looked after, and that he received the necessary care and attention. Her husband's relations with Knopwood however kept on deteriorating, but Andrew seemed to have made at least one last effort to patch things up again by looking him up when Knopwood made a visit to New Norfolk. Knopwood refers to the meeting briefly[63], but it is the last time that Andrew Whitehead is mentioned in his diary - a sad end to a once very strong friendship.

Over the next few years it was Martha's daughter Charlotte who kept on being in the news. When for instance in March 1828 the news of the death of Bowen became known in Hobart Town, the 'Tasmanian' of 22.10.1828 mentions that 'his daughter, Mrs. Dr. Garrett of Pitwater (Sorell) has been well provided for by her late father', another sign that Bowen retained an interest throughout his life in the well being of his daughter. The nature of these provisions are not known - at that time Charlotte and her husband had extensive interests in farming properties in Sorell, near Ross and near Westbury. And well they needed these, as Garrett's competence as a doctor was called into question that same year; later he very likely became an alcoholic and eventually was charged again with incompetence but died from a stroke in December 1834 in Launceston.[64] Robert Garrett should not be confused with his older brother James Garrett who arrived in Hobart Town in December 1828, and who became a well-known Tasmanian preacher.

In the meantime Andrew Whitehead died in 1832, and Martha possibly stayed on at the farm or at least in the Brighton district, because in 1836 an extraordinary news item appeared in the "Cornwall Chronicle":[65]

> 'On the 7th Ultimo (January): Mr. Barnard Williamson, Police Clerk, Brighton, aged 20, to Mrs. Martha Whitehead, aged 50, after a long and tedious courtship of two years'.

We must take this news item as it appeared, but are free to ponder its interpretation. One thing, however, is certain: somebody in the office of the "Cornwall Chronicle" had a very long memory...

Martha's stepfather Stocker died in 1837[66], followed by her mother Mary in 1843 at the ripe old age of 82. Of Martha's own later years little is known, while equally little is known about the 20-year old police clerk who was game enough to marry the 50-year old Martha.

In 1854 two of her granddaughters (Henrietta and Elizabeth) married in a double ceremony in St. Geroge's Church in Battery Point[67], and Martha will also have known most if not all of her great-grandchildren. Her obituary appeared in the "Mercury" of May 15, 1871, followed the next day by a brief salute:

> '*The last of the first* - Our obituary notice records the decease of Mrs. Martha Williamson at the residence of her son-in-law, Mr. Thomas Devine, of Brown's River. In the year 1803 sixty eight years ago, when this colony was founded, the deceased, then Miss Hayes, was the first white woman - or rather English

> young lady, for she was only seventeen - that set foot on the island, and this she effected after a playfull contest for the honour with a less fortunate rival of her own sex, on the flat where it was at that time intended to establish the capital just below the residence of Mr. T.G. Gregson at Risdon or 'Restdown' as they named the spot in those days. With the exception of one lady who still survives, it is supposed that the deceased was the last of the immigrants who formed the first British settlement in the land we live in'.[68]

Martha was buried on Wednesday May 17, 1871, after a service in St. David's Church, the same church which she had seen being built, and which was now about to be demolished to make way for a new cathedral. Her last resting place, probably St. Davids' Cemetery in Davey Street, was not officially recorded.

Martha arrived in Tasmania as a statistic only (in his return to King dated 27th. September 1803 Bowen only describes her as one of the people 'not victualled from the store')[69], and even the location of her last resting place is unknown, two things she had in common with the thousands of other 'female settlers' who came to this island after her.

They were the ones who stood behind (and with) their menfolk, and who collectively laid the foundation of our environment and our present life-style. May we honour them by knowing about them.

REFERENCES

1 - Robson, L.L., 1965: CONVICT SETTLERS OF AUSTRALIA. *Melb. Univ. Press*, p.83.
2 - It is clear from later references that their ages were mixed up in this document; Henry is 35 and Mary is 39.
3 - PRO 2731.
4 - "Glatton" Indent p. 123 *et seq.*; Arch. of NSW. Also HRA 1-3, p.534.
5 - CSO 1/374, file 8531. TSA.
6 - She is definitely not the M. Hayes who advertised later in 1803 in the "Sydney Gazette", as these advertisements continued to appear for some time after Martha's mother had left Sydney for Hobart, early in 1804.
7 - HRA 1-3, p. 132.
8 - "Mercury" 16.5.1871. Strictly speaking she was not the very first European woman to set foot in Tasmania, as it is recorded that the French expedition of D'Entrecasteaux in 1792-93 had a steward on board called Girandin who in fact was a woman in disguise, 'a poor young girl who, betrayed by a disloyal seducer, had fled the righteous anger of her father' as Jurien de la Graviere put it in his 'SOUVENIRS D'UN ADMIRAL' (Paris-1860). Her secret came out when she died shortly after the sick and harrassed crew sailed from Java for France in 1795 (Dunmore, J., 1965: FRENCH EXPLORERS IN THE PACIFIC, I, page 330; Oxford).
It is unlikely that Martha or anyone else in Tasmania at that time knew anything about this.
9 - Recollections of John Hayes - TSA.
10 - HRA 3-1, p.66.
11 - There is no firm indication of the place of origin of Thomas Hayes, while the family tradition is divided in their opinion about his relationship with Henry Hayes.
12 - MS 8, Dixon Library, Sydney.
13 - The matter of the transfer remains puzzling. It clearly states in HRA 3-1, p.56 (King to Collins): 'Thomas Hayes, who came out (as) a settler in the "Ocean" and came here (Sydney) in the "Calcutta", as well as Fletcher the stone mason, with

their families, wish to return to you as settlers. I have therefor given them permission to go in the Integrety for that purpose'. Note 69 on page 797 of that volume does include Henry Hayes among those who transfer from the "Ocean" to the "Calcutta", but note 16 on page 786-787 contradicts note 69. The first mention of Thomas Hayes on page 787 is in all probability an editing error, and should read Henry Hayes. When Henry Hayes is mentioned in the same note he is among those who have gone with Collins to the Derwent. In view of the evidence on hand and the implications of the possible alternatives I have accepted the latter statement as being correct.

14 - HRA 3-1, p. 55.
15 - HRA 3-1, p. 56.
16 - CO 201/33, p. 242 (microfilm 17, TSA).
17 - HRA 3-1, p. 150.
18 - Knopwood 18.2.1804:- M. Nicholls, 1978: KNOPWOODS DIARY, THRA, Hobart.
19 - Hopton, A.J., 1960: J.P. Fawkner, *Vict. Hist. Mag.*, 30: page 38.
20 - see note 9.
21 - Knopwood 29.3.1804.
22 - HRA 3-1, Page 212.
23 - HRA 3-1, page 109.
24 - Knopwood 30.7.1804.
25 - Wentworth papers A 751, pages 161-62, Mitchell Library.
26 - Bethell, L.S., 1958: VALLEY OF THE DERWENT, Dept. Educ., Tasmania, page 21. Several other decendents have told me similar stories, while some have actual articles to show, one of which in particular is very moving indeed, throwing a very sympathetic light on Bowen. Proof of authenticity of such articles always remains very difficult.
27 - HR-NSW 1811, page 496.
28 - CO 201/95, pages 66-67 (microfilm 46, TSA).
29 - Knopwood 25.10.1804.
30 - Knopwood 30.4.1805.
31 - Knopwood 20.8.1805.
32 - Holt, vol.2, page 249; 1848.
33 - HRA 3-1, page 255.
34 - HRA 3-1, pages 422-23.
35 - MS 8, Dixon Library, Sydney.
36 - HTG 18.7.1818.
37 - HRA 3-1, pages 555 and 558.
38 - CSO 1/374 file 8531, TSA.
39 - Macquarie: JOURNAL etc. 1810-1822, Publ. Library of NSW, page 57.
40 - The present cottage may date from about 1840, with additions of later dates.
41 - Oxley Report of 1810, page 573.
42 - HRA 3-2, page 65.
43 - HRA 3-2, page 62.
44 - Knopwood 29.6.1814.
45 - Knopwood 14.7.1814 and 8-9.4.1815.
46 - Knopwood 14.12.1815.
47 - HRA 3-3, page 572 (spring 1817).
48 - HTG 24.10.1818 and Knopwood 20.8.1817.
49 - HTG 1.11.1817.
50 - Knopwood 5.1.1814.
51 - Knopwood 28.3.1816.
52 - HTG 8.5.1819.
53 - HTG 29.6.1816.
54 - HTG 2.5.1818
55 - HTG 3.10.1818.
56 - Knopwood 15.11.1819.
57 - HRA 3-3, page 681.

58 - Knopwood 11.2.1820.
59 - Knopwood 21.6.1823.
60 - Lord, R., 1976: INSCRIPTIONS IN STONE. Hobart, page 170.
61 - HTG 14.4.1822.
62 - HTG 6.12.1823.
63 - Knopwood 8.10.1825.
64 - Independent 13.12.1834.
65 - Cornwall Chronicle 16.1.1836.
66 - Lord, R., 1976: INSCRIPTIONS IN STONE. Hobart, page 185.
67 - H.T. Courier 14.6.1854.
68 - Notes: 1/'the residence of her son-in-law': now the 'Southlea' property of Mr. John Walch along the Southern Outlet Road. 2/'One lady who still survives': although the number of women in the original Bowen settlement was very small I was unable to determine who she was.
69 - In the language of the day this meant that she was a member of a domestic situation in which someone else was the main provider. Collins later frequently used similar descriptions to indicate the wives, children and domestic staff of settlers.

Papers and Proceedings of the Royal Society of Tasmania, Volume 113, 1979

(ms. received 21.12.1978)

A NEW SPECIES OF STINGRAY (F. DASYATIDAE) WITH A KEY TO THE AUSTRALIAN SPECIES

by P.R. Last
Tasmanian Fisheries Development Authority, Taroona, Tasmania

(with one table and two text figures)

ABSTRACT

LAST, P.R., 1979 (20 vii): A new species of stingray (F. Dasyatidae) with a key to the Australian species. *Pap. Proc. R. Soc. Tasm.*, 113: 169-176. ISSN 0080-4703. Tasmanian Fisheries Development Authority, Taroona, Tasmania, Australia.

Eleven species of dasyatids, *Amphotistius kuhlii* (Müller and Henle), *Dasyatis brevicaudatus* (Hutton), *D. fluviorum* Ogilby, *D. guileri* sp. nov., *D. sephen* (Forskal), *D. thetidis* Waite, *Himantura granulata* (Macleay), *H. uarnak* (Forskal), *Taeniura brocki* Schultz, *T. lymma* (Forskal) and *Urogymnus asperrimus* (Bloch and Schneider) are recognised as occurring in Australian waters. The new species is described and figured. The Australian species are keyed but no attempt was made to unravel the complicated generic synonymy of the group.

INTRODUCTION

Two major schools of thought exist regarding the family status of the Dasyatidae. Several authorities (Fowler, 1941; Garman, 1913; Herald, 1961; Lord and Scott, 1924; Scott, 1957; Smith, 1950; Stead, 1963; Waite, 1923) recognised a family group which now includes about ninety species, including the Australian genera *Dasyatis, Taeniura, Urogymnus, Urolophus* and *Gymnura*; the genus *Dasyatis* was split by Fowler (1941) into the four subgenera: *Himantura, Pastinachus, Dasyatis* and *Amphotistius*.

Many recent authors (Bigelow and Schroeder, 1953; Compagno, 1973; Grant, 1975; Munro, 1956; Scott, 1962; Scott, Glover, and Southcott, 1974) have given *Urolophus* and *Gymnura* separate family status and elevated Fowler's subgenera to genera.

McCulloch (1929), employed the former system but recognised *Himantura* and *Pastinachus* as distinct genera and checklisted seventeen species from Australia.

These species are: (1) *Dasyatis brevicaudatus* (Hutton, 1875); (2) *D. fluviorum* Ogilby, 1908; (3) *D. thetidis* Waite, 1899; (4) *D. kuhlii* (Müller and Henle, 1841); (5) *Pastinachus sephen* (Forskal, 1775); (6) *Himantura uarnak* (Forskal, 1775); (7) *Taeniura lymma* (Forskal, 1775); (8) *T. mortoni* Macleay, 1883; (9) *T. meyeni* Müller and Henle, 1841; (10) *Urogymnus asperrimus* (Bloch and Schneider, 1801); *Urolophus sufflavus* Whitley, 1929; *U. cruciatus* (Lacépède, 1804); *U. expansus* McCulloch, 1916; *U. testaceus* (Müller and Henle, 1841); *U. viridis* McCulloch, 1916; and *Pteroplatea australis* (Ramsay and Ogilby, 1885) which according to Marshall (1964) is a junior synonym of *Gymnura australis*.

Whitley (1933) erected *Toshia* and *Bathytoshia* with type species *Dasyatis fluviorum* and *D. thetidis* respectively. Although these generic names have been applied (Gudger, 1937), some authors (Richardson and Garrick, 1953) considered their formation unfounded. Whitley (1940) elevated *Urogymnus* and *Urolophus* to family status but retained *Gymnura* within the Dasyatidae. Apart from including 1 (above) in his *Bathytoshia*, 9 was expunged from the list; the latter specimen being a misidentification of 7. Another two *Himantura* species, (11) *H. granulata* (Macleay, 1883) and (12)

H. toshi Whitley, 1939, were added.

Munro (1956), followed the latter school by excluding *Urolophus* and *Gymnura*, and recognised only nine species. Species 1, 2, 3, 6, 7, 10 and 11 were included as above, with 5 as *Dasyatis sephen* and 4 as *Amphotistius kuhlii*; 8 and 12 were not included.

Allen *et al.* (1976) added *Taeniura brocki* Schultz, 1953, from Lord Howe Island.

METHOD

As the author was unable to examine specimens of all the Australian species, the following key was constructed largely from the literature and uses those genera recognised by Bigelow *et al.* 1953. The Australian distribution of each species is also included. Those localities marked with asterisks represent likely occurrences that have not officially been recorded in the literature; the abbreviations for each state being: New South Wales (N.S.W.), Northern Territory (N.T.), Queensland (Qld), South Australia (S.A.), Tasmania (Tas.), Victoria (Vic.) and Western Australia (W.A.).

KEY TO THE SPECIES OF DASYATID RAYS RECORDED FROM AUSTRALIA

1. Disc oval; width less than length 2
   Disc quadrangular or rounded; width greater than or equal to length 3

2(1). Disc studded with tubercles and bucklers. Tail without stinging barbs ..... *Urogymnus asperrimus* (Qld).
   Disc smooth except for some flattened tubercles along midline. Stinging barbs present ..... *Taeniura lymma* (N.T., Qld, W.A.).

3(1). Dorsal spine inserted on posterior half of tail. Body whitish with dark spots and blotches *Taeniura brocki* (Lord Howe Is.).
   Dorsal spine inserted on anterior half of tail 4

4(3). No cutaneous folds on tail 5
   Tail with upper, lower or both cutaneous folds; folds sometimes very narrow 6

5(4). Tail greater than 2.25 length of disc; banded with about 35 blackish blue rings *Himantura uarnak* (N.S.W., N.T., Qld, W.A.).
   Tail less than 2.25 length of disc; without rings .... *Himantura granulata* (N.T., Qld, W.A.).

6(4). Tail less than 1.75 length of disc 7
   Tail greater than 1.75 length of disc 9

7(6). Tail with both upper and lower cutaneous folds. Disc spotted. ..... *Amphotistius kuhlii* (N.S.W., N.T., Qld, W.A.*).
   Tail with cutaneous fold only on lower surface. Disc not spotted 8

8(7). Disc with rows of large spiny tubercles on dorsal surface .... *Dasyatis thetidis* (N.S.W., S.A., Tas., Vic.*, W.A.).
   Disc smooth, without rows of spiny tubercles on dorsal surface although one small oval tubercle may be present ....*Dasyatis brevicaudatus* (N.S.W., S.A., Tas., Vic., W.A.).

9(6). Tail with very broad cutaneous fold on lower surface; not typically whiplike. Disc with one or two large central tubercles .... *Dasyatis sephen* (N.S.W., N.T., Qld, W.A.).
   Tail with narrow cutaneous fold on lower surface; typically whiplike. Disc with a row of tubercles extending on to tail 10

10(9). Dorsal surface of disc olive brown, ventral surface white .... *Dasyatis fluviorum* (N.S.W. Qld).
   Dorsal and ventral surfaces black ..... *Dasyatis guileri* sp. nov. (Tas.).

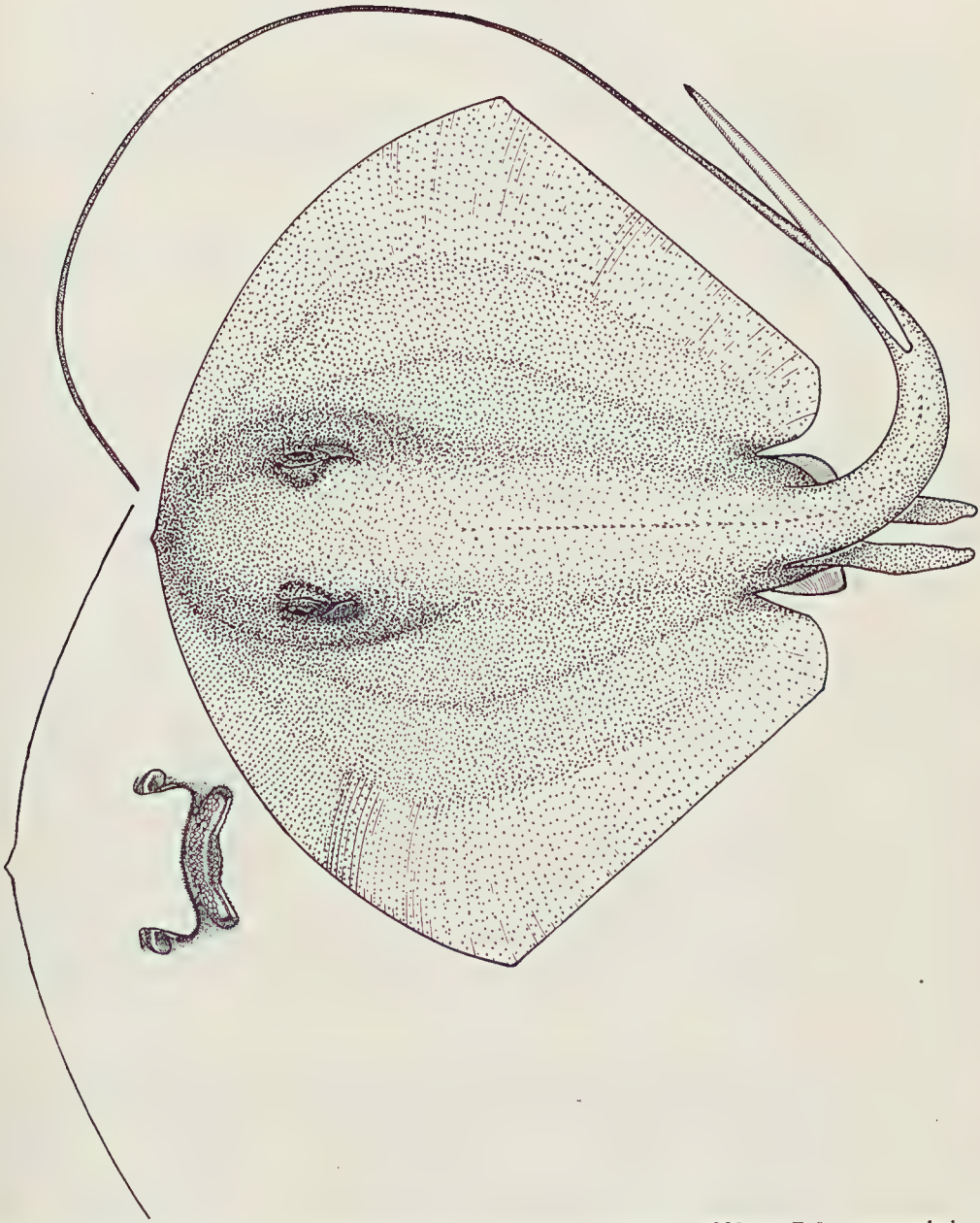


FIG. 1a (main figure).- *Dasyatis guileri* sp. nov.; holotype; 889 mm T.L.; stranded, Nutgrove Beach, Derwent River estuary; April, 1977; Queen Victoria Museum Reg. No. 1978/5/108, Type 360; x 1/3.

1b (bottom left).- Anterior ventral aspect showing buccal area; x 1/2.

A New Species of Dasyatid Stingray

Family DASYATIDAE
Genus *DASYATIS* Rafinesque 1810
Dasyatis guileri sp. nov. (Figure 1)

Material

Holotype: 889 mm total length, male, collected by Dr. E.R. Guiler, stranded, Nutgrove Beach, Derwent River Estuary, (147° 21'E, 42° 55'S), Queen Victoria Museum Reg. No. 1978/5/108, Type 360.

Description

Body depressed, thick, antero-lateral margin moderately convex; posterior and lateral apices of pectoral fins angular. Snout tip rudimentary, barely distinguishable from anterior profile. Head wide, distinguishable from disc. Snout profile in front of eyes moderately concave, becoming slightly convex to snout tip.

Tail stout, with two spears; profile gently tapered to base of second spear then thin and whiplike to extremity; anterior to spear base, smooth except for a two of 21 large and 10 small tubercles extending along mid dorsal surface; posterior to spear base is lacking any form of spination but irregular in cross section due to very fine longitudinal furrows; narrow cutaneous fold extending posteriorly along ventral surface from below origin of large spear to approximately 0.75 post-spinal length; dorsal surface without fold. Primary spear large, tapering; 2.3 times length of snout; dorsal surface slightly convex laterally, ventral surface elevated to form prominent ridge; lateral edges with paired rows of 93, 92 sharp serrations each directed anteriorly and imperfect proximally; very sharp distally. Secondary spear small; 0.17 in primary; partly sunken in a deep groove on the dorsal surface of the tail.

Disc smooth except for a row of 32 sharp tubercles extending from disc centre along dorsal midline to join those on tail. Large sensory pores concentrated around midline of snout then bifurcating to form U patterns around both eyes. Microscopic sensory pores scattered over disc and tail. Eyes small, lateral, raised above interorbital. Gill slits small, sigmoid. Spiracles oblique, slightly larger than eye. Internasal flap broad, subrectangular; slightly wider than mouth; marginally wider posteriorly than anteriorly; lateral edges smooth; posterior edge rather concave; frenum stout mesially. Mouth moderately proconvex. Upper lip imperfect. Lower lip plicate. Buccal structures indiscernible. Teeth arranged in pavement, quincuncially; occlusal surface slightly convex; more acute mesially; 61 visible in upper jaw, 78 visible in lower jaw (these values may be higher as posterior section of both jaws occluded). Nostrils ovoidal, less than eye diameter. Pectorals wide, anterior margin smooth and convex; acute at tip; posterior lateral margin sinuous, rectilinear; acute posteriorly then slightly convex to posterior base. Pelvic fins small, smooth, sinuous; rectilinear along anterolateral margin; convex distally; insertion forming deep notch with pectoral. Claspers stout, longer than snout.

Dimensions

As given in Table 1. Table 1 constitutes a summary of the dimensions of the holotype; the first measurement is absolute in millimetres, while the second is expressed as a proportion in millesimals of disc length. Hubbs and Ishiyama (1968) define the disc length for rajids, as the greatest distance from snout tip to posterior margin of the pectoral fin. Although this length is included, the measurement represented by the distance from the snout tip to posterior margin of the anus was considered more reliable and herein deemed to be the disc length. All dimensions were taken as direct measurements.

Coloration

Dorsal surface uniform black, tubercles and posterior third of spear white. Ventral surface brownish black with a few lighter flecks. Whiplike section of tail and cutaneous fold black. Anus white. Teeth yellow.

TABLE 1

DASYATIS GUILERI SP. NOV.

Dimensions of holotype from the Derwent Estuary, Southern Tasmania. Measurements given as absolute (mm) and relative dimensions (thousandths of disc length).

	Absolute dimensions (mm)	Relative dimensions (thousandths of disc length)
Length:		
Disc	251	
Total	889	3 541
Snout	60	239
Eye	14	56
Pelvic fin, right	50	199
Tail	638	2 542
Spear 1	141	562
Spear 2	24	96
Snout tip to base of spear 1	354	1 410
Snout tip to anterior border of anus	231	920
Snout tip to anterior apex of right pectoral fin.	226	900
Snout tip to posterior apex of right pectoral fin.	271	1 080
Snout tip to apex of right pelvic fin	278	1 108
Snout tip to anterior border right spiracle.	76	303
Snout tip to anterior border right nostril.	42	167
Snout tip to middle of upper lip	44	175
Snout tip to first right gill slit	92	367
Snout tip to last right gill slit	128	510
Anterior border of anus to apex of right clasper.	98	390
Between anterior and posterior apices of right pectoral fin.	167	665
Width:		
Maximum	348	1 386
Between posterior apices of pectoral fins	112	446
Between posterior apices of ventral fins	41	163
Between spiracles	63	251
Between nostrils	38	151
Between first gill pair	65	259
Between last gill pair	45	179
Mouth	34	135
Interorbital	61	243
Base of tail	31	124
Base of spear 1	13	52
Depth:		
Maximum	63	251

Nomenclature

This species is named in honour of the collector Dr. E.R. Guiler, who noticed the freshly stranded specimen on a Hobart beach.

Affinities

Of the Australian species *D. guileri* most superficially resembles *D. fluviorum*. Both species possess a characteristically long whiplike tail which is greater than twice the disc length. However the species are quite different in body coloration and disc shape; the former trait was used as a key character. The disc of *D. guileri* is uniquely angular at its lateral extremities and the antero-lateral profile moderately convex, while in other Australian dasyatids the profiles are rounded, and straight or only slightly convex, respectively. *D. fluviorum* also possesses a prominent tail fold on the dorsal surface posterior to the spear; this character is absent in *D. guileri*.

Two species of *Dasyatis*, *D. thetidis* and *D. brevicaudatus*, have been recorded from Tasmania; both attain huge sizes and are amongst the largest dasyatids in the world. Consequently the juveniles are similar in size to the holotype of *D. guileri*. Waite (1899) gave a short account of a juvenile *D. thetidis* and stated that the specimen was very similar to the adult except for a slightly more elongated tail. A small relative elongation of the tail was also observed by the author for juveniles of the stingaree *Urolophus cruciatus* (Lacépède). However *D. guileri* should be easily distinguishable from juveniles of the larger dasyatids by the disc shape and colour.

A Formosan species, tentatively identified and figured by Jordan and Richardson (1909) as *D. bennetti* (Müller and Henle), appears to be the most similar species to *D. guileri*. Fowler's (1941) description of *D. bennetti* portrayed a completely different species and he linked Jordan *et al's* specimen with *D. navarrae* (Steindachner). The Formosan species is similar to *D. guileri*, but differs by possessing a short dorsal fold and minute tubercles posterior to the spear. Undoubtedly the most diagnostic feature separating *D. guileri* from all other long tailed dasyatids is the relatively enormous spear; the length is greater than twice the snout length, barely once in other species.

DISCUSSION

Any person undertaking a literature search of the systematics of the Dasyatidae is immediately greeted with taxonomic confusion. Generic diagnoses and keys are permeated with characters that are either vague or variable. This problem has been compounded by the virtual absence of information on intraspecific and ontogenetic variation. Furthermore, the reliability of previous revisions has been influenced by the absence of representative material of each species. Stingrays generally are large animals and this poses obvious problems with storage. Consequently representation of the family tends to be poor or non-existent in museum collections. Such problems can only be overcome by improving storage facilities and more extensive collecting.

Clearly, a generic revision based solely on literature reviews would be unreliable. Consequently no attempt was made to alter generic definitions, so the classification proposed by Bigelow *et al.* and supported by the phylogenetic studies of Compagno (1973), was utilised as the basis for this account.

The isolation and recognition of entities at the specific level appears to be more reliable. Those species listed by Munro (1956) appear to be good species and along with *Taeniura brocki* and *Dasyatis guileri*, form the complement of Australian species.

ACKNOWLEDGEMENTS

I wish to thank Mr. R. Green for his diagram of the holotype. I am also grateful to Doctors J. Dixon, C.J.M. Glover and D.F. Hoese for checking holdings at their respective museums. Finally I would like to thank Mrs. F.T. Reynolds for typing and Mr. A.P. Andrews for criticizing the manuscript.

REFERENCES

Allen, G.R., Hoese, D.F., Paxton, J.R., Randall, J.E., Russell, B.C., Starck II, W.A., Talbot, F.H. and Whitley, G.P., 1976: Annotated checklist of the fishes of Lord Howe Island. *Rec. Aust. Mus.*, 30(15): 365-454, figs 1-2.

Bigelow, H.B. and Schroeder, W.C., 1953: Chapter one, sawfishes, guitarfishes, skates and rays. *Mem. Sears Fdn mar. Res.*, 1(2): 1-514.

Compagno, L.J.V., 1973: Interrelationships of living elasmobranchs. In Greenwood, P.H., Miles, R.S. and Patterson, C. (Eds): INTERRELATIONSHIPS OF FISHES, 15-61. Academic Press.

Fowler, H.W., 1941: The fishes of the groups Elasmobranchii, Holocephali, Isospondyii and Ostarophysi obtained by the United States Bureau of Fisheries Steamer "Albatross" in 1907 to 1910, chiefly in the Phillipine Islands and adjacent seas. *Bull. U.S. Natn. Mus.*, 100(13): i-x, 1-879.

Garman, S., 1913: The Plagiostoma. *Mem. Mus. comp. Zool. Harv.*, 36: i-xiv, 1-515.

Grant, E.M., 1975: GUIDE TO FISHES. Co-ordinator General's Department, Brisbane, Queensland.

Gudger, E.W., 1937: *Bathytoshia*, the Giant Stingaree of Australia. *Aust. Mus. Mag.*, 6: 205-210, 4 figs.

Herald, E.S., 1961: LIVING FISHES OF THE WORLD. Hamish Hamilton L.T.D., London.

Hubbs, C.L. and Ishiyama, R., 1968: Methods for the taxonomic study and description of skates (Rajidae). *Copeia*, 3: 483-491.

Jordan, D.S. and Richardson, R.E., 1909: A Catalog of the fishes of the island of Formosa, or Taiwan, based on the collections of Dr. Hans Sauter. *Mem. Carn. Mus.*, 4(4): 159-204, 29 figs, pls LXIII-LXXIV.

Lord, C.E. and Scott, H.H., 1924: A SYNOPSIS OF THE VERTEBRATE ANIMALS OF TASMANIA. Oldham, Beddome and Meredith, Hobart.

Marshall, T.C., 1964: FISHES OF THE GREAT BARRIER REEF. Angus and Robertson, Sydney.

McCulloch, A.R., 1929: A checklist of the fishes recorded from Australia. *Aust. Mus. Mem.*, 5 (1-4) (part 4, Index, 1930): i-x, 1-534.

Munro, I.S.R., 1956: Handbook of Australian fishes, 4: 17-20. *Fisher. newsl.* (now *Aust. Fisher.*), 15(10).

Richardson, L.R. and Garrick, J.A.F., 1953: *Dasyatis thetidis* Waite, a second species of Giant Stingray in New Zealand Waters. *Trans. R. Soc. N.Z.*, 81: 319-320.

Scott, E.O.G., 1957: Observations on some Tasmanian Fishes. Part VIII. *Pap. Proc. R. Soc. Tasm.*, 91: 145-156.

Scott, T.D., 1962: THE MARINE AND FRESHWATER FISHES OF SOUTH AUSTRALIA. Government Printer, Adelaide.

_____, Glover, C.J.M. and Southcott, R.V., 1974: THE MARINE AND FRESHWATER FISHES OF SOUTH AUSTRALIA. Government Printer, Adelaide.

Smith, J.L.B., 1950: THE SEA FISHES OF SOUTHERN AFRICA. Central News Agency, South Africa.

Stead, D.G., 1963: RAYS AND SHARKS OF AUSTRALIAN SEAS. Angus and Robertson, Sydney.

Waite, E.R., 1899: Scientific results of the trawling expedition of the H.M.C.S. "Thetis", Introduction and fishes. *Aust. Mus. Mem.*, 4: 1-132, frontispiece, pls i-xxx, text figs 1-10.

_____, 1923: THE FISHES OF SOUTH AUSTRALIA. Government Printer, Adelaide.

Whitley, G.P., 1933: Studies in ichthyology. No. 7. *Rec. Aust. Mus.*, 19(1): 60-112, pls 11-15, figs 1-4.

Whitley, G.P., 1940: THE FISHES OF AUSTRALIA. Part 1. THE SHARKS, RAYS, DEVIL FISH, AND OTHER PRIMITIVE FISHES OF AUSTRALIA AND NEW ZEALAND. Royal Zoological Society of New South Wales, Sydney.

Papers and Proceedings of the Royal Society of Tasmania, Volume 113, 1979.

(ms. received 23.5.1978)

ANPHILAEMON KINGI gen. et sp. nov., A LAND-LEECH ON KING ISLAND, BASS STRAIT (HAEMADIPSOIDEA: DOMANIBDELLIDAE).

by Laurence R. Richardson
Grafton, New South Wales

(with one text figure)

ABSTRACT

RICHARDSON, L.R., 1979 (20 vii): *Anphilaemon kingi* gen. et sp. nov., a land-leech on King Island, Bass Strait (Haemadipsoidae: Domanibdellidae). *Pap. Proc. R. Soc. Tasm.*, 113: 177-184. ISSN 0080-4703. 4 Bacon Street, Grafton, New South Wales, Australia.

Anphilaemon, Philaemoninae, distinctive in having the nephropores on *ix* a_1, *x* a_1, anterior, close to *viii/ix*, *ix/x*, in the middle of *xi* a_1; differs from *Philaemon* s.s. in having the paramedian somital sense organs included in the borders of the median dorsal dark band; a continuous narrow contrast stripe along the medial edge of the paramedian field, the field completed by a dark band extending across the intermediate field, with the intermediate sense organs median and the supramarginals lateral in the band.

INTRODUCTION

This new species is known in three specimens from King Island in the collections of the United States National Museum. This is the first record of land-leeches on an island in Bass Strait.

The general morphology of the species is typical of the Philaemoninae, the subfamily containing the 4-annulate land-leeches of continental Australia east of the Dividing Range from North Queensland to Victoria, Tasmania, and Lord Howe Island. All known land-leeches of Victoria and Tasmania, belong to this subfamily.

There has been major difficulty in systematizing the Philaemoninae at the southern end of its distribution. The type genus for the subfamily is *Philaemon*, a name proposed by Blanchard (1897), but lacking description or definition until 1917, and defined then only as 4-annulate, auriculate, with the type species *Philaemon pungens*. Blanchard and Lambert describe the somital annulation in the manner of Whitman: 26 preanal somites; the annulus containing the somital ganglion, recognized as the anterior annulus of the somite, and the following nephroporic annulus as the posterior annulus of the somite. Their descriptions are converted here to the somital annulation of Moore: 27 preanal somites; the somital ganglion central in the somite, and the nephroporic annulus anterior to this, as belonging to the somite.

There is a discrepancy between Blanchard's description of *P. pungens* as having the genital pores at *xi* b_5/b_6 and *xii* b_5/b_6, and his fig. 7 showing the pores at *xi* b_5/b_6, *xii* a_2/b_5. The location of the female pore indicates the figure was based on the specimen he lists as from the Richmond River, northern N.S.W., and not on *pungens*. Blanchard (Soós 1967) also placed in *Philaemon* species from Samoa, Java, and Madagascar, in this way assembling an unacceptably heterogeneous genus. The species in Samoa is now in the Leiobdellinae; in Madagascar, in the Malagabdellinae (Richardson 1975; in press).

Lambert (1898) provided a closely detailed description of the external and internal morphology of *Philaemon pungens*, basing this on specimens from southern Victoria

and Tasmania.

Lambert described: organs attached to the postcaeca, now the lambertian organs; the compact arrangement of somital ganglia *xxiv* to *xxvii* and the posterior ganglionic mass; the anterior regions of the male paired ducts elaborated on posteriorly directed primary loops within the median splanchnic chamber; the median region of the female reproductive system as formed on a posteriorly directed loop with the posterior face of the elbow of the loop expanded as an oviducal glandular sac; the absence of albumin glands; and other morphology known now as characteristic of the Haemadipsoidea.

With this evidence in a pioneer paper of such a high level of zoological competence, it can be accepted at this time only that the form of the male median region, fig. 2, is as shown: a wide organ in the contiguous annuli of *xi* and *xii*, the width some 6 times the width of nerve cord ganglia; dorsal to the nerve cord; the dorsal aspect bilobed; the anterior ends of the male paired ducts each terminating on the dorsal surface of a lobe. The size, relationship to the nerve cord, etc., is such as I term mesomorphic.

In 4-annulates from North Queensland to Victoria and Tasmania, I have not yet seen a male median region as shown by Lambert. In all I have dissected, the male median region is as in the new species: a simple thin-walled sac, minute, of the size of a nerve cord ganglion to little more than twice this size, ventral to the nerve cord, and with the male paired ducts joining independently to the atrium, low on the anterior face of the atrium. I term this form amyomeric, micromorphic. It was because of this that I was unable (1975) to assess the generic status of the 4-annulate land-leeches in Tasmania.

There are two species currently assigned to *Philaemon* s.s.: *P. pungens* as in Lambert (1898) and *P. grandis* Ingram 1957. Ingram assigned Tasmanian specimens to *pungens*, but the description is inadequate for consideration here. The male median region is micromorphic in *grandis* (*v.* Ingram, fig. 5).

The dorsal pattern in *pungens* (Lambert, fig. 3) and *grandis* is: a longitudinal dark band restricted to the median field; on each side of this, a light contrast stripe along each line of the paramedian somital sense organs as segments between a_2 and a_2 along the length of the body in *pungens*, coalescing in the mid-body region in *grandis* to form irregular longitudinal stripes; in *pungens*, a wide longitudinal brown band lateral to each stripe, the band occupying the paramedian field, the line of the intermediate somital sense organs, the intermediate field, and the line of the supramarginal sense organs, in *grandis* a wide dark band "uniform in life"; *pungens* lacking a marginal contrast stripe (Lambert refers to "the lateral edge where the dark dorsal area meets the pale ventral surface"), *grandis* with a marginal contrast stripe intact anteriorly and broken posteriorly into segmental patches.

Ingram noted that preserved specimens of *grandis* have the dorsal surface brown, with "four longitudinal darker-brown stripes in the paramedian and paramarginal positions", interpretable from the above as along the medial and lateral edges of each of the paired dark dorsal bands, i.e. the medial edge lateral to the line of the paramedian somital sense organs, as also in *pungens*.

The King Island leeches differ from the above: the median dark band occupies the median field and includes the lines of the paramedian sense organs, the sense organs being in the darker edges of the band; a narrow light contrast stripe along the medial edge of the paramedian field, intact along its length; a wide dark band completes the paramedian field, includes the line of the intermediate sense organs which are central in the width of the band, the band extending across the intermediate field to include the line of the supramarginal sense organs, the band with a medial dark margin and a

lateral dark margin in the intermediate field extending into the upper portion of the marginal field; below this, the marginal field pale, continuous with the venter anteriorly; i.e. preserved, a total of 6 dark brown margins on the dorsal bands.

Lambert described the nephropores in *pungens* as opening "on the posterior edge of the annulus"; Ingram, in *grandis* as "visible on the caudal borders of the first annulus in *ix* to *xxiii*".

The King Island specimens show a novelty not known to me before in land-leeches. The nephropores in *ix, x,* are anterior on a_1, close to *viii/ix* and to *ix/x;* in *xi,* central in the length of the surface of a_1; and in *xii* to *xxiii,* posterior on a_1, close to a_1/a_2.

I have added three genera to the Philaemoninae: *Xenobdella* based on *X. rubra* Richardson 1975 of Lord Howe Island, with *xxiv* 2-annulate, the genital pores at *xi/xii* (*xi* b_6), *xii* a_2/b_5 (a_2), and lacking lambertian organs. The other two have the general somital annulation, jaws, lambertian organs etc., as in *Philaemon* s.s.: *Castrabdella* based on *C. nymboidae* Richardson 1975 of north-eastern New South Wales, resembles *Philaemon* s.s. in having a contrast stripe along each line of paramedian sense organs, differs in having a second contrast stripe lateral in each intermediate field, the stripe including the supramarginal sense organs, the genital pores *xi* b_5/b_6 (*xi* b_6), *xii* a_2, and distinctly small lambertian organs; *Micobdella,* based on *M. gloriosi* Richardson, 1974 of south-eastern Queensland, has a contrast stripe along the length of the median field, the paramedian sense organs within the medial edge of a dark band extending into the middle of the intermediate field with the intermediate sense organs within the band, and from in *vi* to in *xxvi* a contrast stripe completing the intermediate field with the supramarginal sense organs close to the outer edge of the stripe.

The continuing experience of the jawed leeches in Australia confirms the topographic stability of the dorsal pattern and its systematic values in aquatic and terrestrial sanguivores. In both, the topography of the pattern in the dorsal median and paramedian areas is stable at generic and lower levels in genera separable on general somital annulation and/or other morphological features. In such genera, differences in the topography of the pattern in the dorsal intermediate and marginal areas have been demonstrated to have specific value in some (Richardson 1971, 1974).

On the above basis, it is proper to propose a new genus for the land-leeches on King Island.

Sub-family PHILAEMONINAE

ANPHILAEMON gen. nov.

Derivation: an-, negative prefix in Greek + *Philaemon,* a generic name in zoology.

General somital annulation, lambertian organs, etc., as in *Philaemon* s.s.; jaws with a continuous row of minute teeth; no salivary gland papillae; *xxiv* uniannulate; 6 annuli on the dorsum between *xxiii* a_2 and the anus; auricles small, posterior to *xxv*; nephropores anterior on a_1 in *ix, x,* central in *xi,* posterior in *xii* to *xxiii;* a median dark band filling the median field extending to include the paramedian somital sense organs; a narrow continuous light stripe along the medial edge of each paramedian field; the paramedian fields completed by a dark band including the line of the intermediate somital sense organs, central in the band, and extending across each intermediate field to include the line of the supramarginal somital sense organs; genital pores, *xi* b_5/b_6, *xii* b_5/b_6; ejaculatory bulbs present; male median region amyomeric, micromorphic.

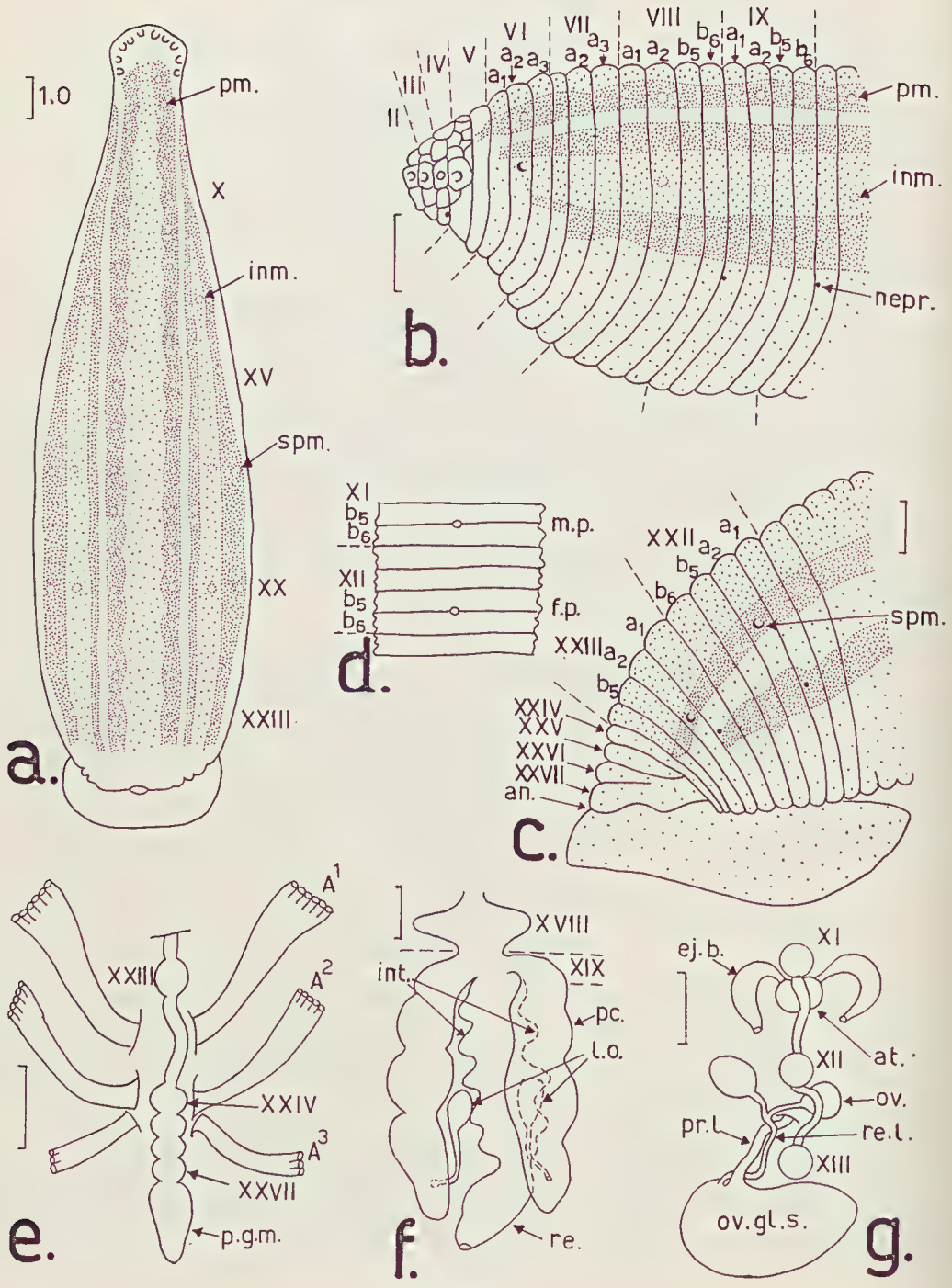

1.0
pm.
X
inm.
XV
spm.
XX
XXIII
a.
II
III
IV
V
VI
VII
VIII
IX
pm.
inm.
nepr.
b.
XI
m.p.
XII
f.p.
d.
XXII
spm.
XXIII
XXIV
XXV
XXVI
XXVII
an.
c.
A1
A2
A3
XXIII
XXIV
XXVII
p.g.m.
e.
XVIII
XIX
int.
pc.
l.o.
re.
f.
ej.b.
XI
XII
at.
ov.
pr.l.
re.l.
XIII
ov.gl.s.
g.

FIGURE 1

Type Species: *Anphilaemon kingi* sp. nov., King Island, Bass Strait.

ANPHILAEMON KINGI sp. nov.
Figure 1

Material: "U.S.N.M. Haemadipsidae. 3 spec. King Island, Bass Strait, Tasmania. A.R. Cheese, coll. Moore, donor. Acc. 259718." No date given. All three specimens are strongly contracted, curved ventrally: (a) 14.5 mm long; (b) ca. 25.0 mm; (c) 27.0 mm; paratype (b) deposited in the Tasmanian Museum.

The following description is based on (a) Nat. Mus. Nat. Hist., No. 55608, which I select as the type specimen. Colour, pattern, and the location of the nephropores on *ix*, *x*, *xi*, in (b), (c), as in the type.

Description

General Form

Contracted to be broad-bodied; the dorsum low convex, the margins obtusely rounded, and the venter shallowly concave. Widest posteriorly at about 10.0 mm from the anterior border of the sucker, the width 5.0 mm, the depth 2.0 mm; narrowing gradually anteriorly to be 4.0 mm at 5.0 mm, and 2.0 mm at *vi/vii*; the width reducing more rapidly posteriorly, the depth 3.0 mm, to form the base for the posterior sucker which is narrower than the width of the body, nearly 3.0 mm wide and long, with a small obtuse clamp.

Colour

Preserved. Dark brown across the dorsum, divided longitudinally by six narrow darker bands; the margins and venter, paler, uniform greyish brown; the dorsum and venter of the posterior sucker, dark cream.

Pattern (fig. 1. a, b, c)

Preserved. A dark band with narrow darker borders occupies the dorsal median field, with the lines of the paramedian somital sense organs in the dark borders from in *vi* to in *xxiii*. In the median field, the band takes its colour from dark areolae and contrasting paler areolae, the general distribution of the paler areolae producing the appearance of a pale median "stripe" which is very irregular along its length.

FIGURE 1

Anphilaemon kingi gen. et sp. nov.

Figures based on the type. a. Topography of the dorsal pattern (semidiagrammatic). General somital annulation and topography of pattern: b. left lateral view, somites *ii* to *ix*; c. right lateral view, somites *xxii* to *xxvii*, and posterior sucker. d. Location of genital pores (not to scale). e. Posterior somital ganglia, posterior ganglionic mass, mm. habenae of the A group; dorsal aspect. f. Crop compartments *xviii*, *xix*, postcaeca, lambertian organs, intestine, rectum, left postcaecum displaced laterally; dorsal aspect. g. Anterior ends of male paired ducts, male median region, female reproductive systems, oviducal glandular sac displaced posteriorly; dorsal aspect.

Somites and somital ganglia indicated by roman numerals; annuli, "a_2" etc.; somites, broken lines; somital ganglia shown at relative size; scales in mm, 0.5 mm or as indicated.

Abbreviations: A^1, A^2, A^3, mm. habenae; an., anus; at., atrium; ej.b., ejaculatory bulb; f.p., female pore; inm., intermediate somital sense organ; int., intestine; l.o., lambertian organ; m.p., male pore; nepr., nephropore; ov., ovary; ov. gl.s., oviducal glandular sac; pc., postcaecum; p.g.m., posterior ganglionic mass; pm., paramedian somital sense organ; re., rectum; re.l., recurrent, and pr.l., procurrent limbs of the female median region; spm., supramarginal somital sense organ.

A narrow contrast stripe along the median third of the paramedian field in *vi* to in *xxiii*.

A wide dark band with a narrow darker medial border completes the paramedian field, includes the line of the intermediate somital sense organs which are central in the band, the band extending across the intermediate field has a wide lateral dark border which includes the supramarginal sense organs (recognizable in *xv* to *xxi*), the two dark borders of the band fusing anteriorly.

The marginal fields are occupied above by the dark border of the paired band, and below this, maculated rather irregularly giving the impression of a faded pale stripe in the upper portion of the marginal field, this including the nephropores anteriorly, with the posterior nephropores in a pale band darker than the venter.

The fading after preservation of rather uniform dark bands into a paler median portion with dark edges, is seen in many land-leeches (Richardson 1974).

Allowing for this, the dorsal pattern in life for this species would be: a wide dark median band including the lines of the paramedian somital sense organs, the band separated by a narrow contrast stripe close to the median edge of the paramedian field, from a wide dark band extending across the paramedian field, the line of the intermediate somital sense organs, the intermediate field, the line of the supramarginal sense organs, and briefly into the marginal field; a narrow contrast stripe with a straight dorsal margin completing the marginal field, and possibly continuous with the venter.

Annulation (fig. 1. b,c)

Contracted; the intersomital and interannular furrows, deep, equivalent; the annuli compressed; areolation reduced along much of the body; somital sense organs commonly recognizable; nephropores, generally readily recognizable on *xii* to *xxiii*, but requiring careful examination on *ix* to *xi*.

The 1st nephropores are ventral to the ocular areolae of *iv*, *v*; the 2nd nephropores, anterior on *ix* a_1 and close to *viii/ix*; the 3rd, anterior on *x* a_1, close to *ix/x*; the 4th, in the middle of the length of *xi* a_1; the 5th to 16th, on *xii* to *xxiii*, posterior on a_1 close to a_1/a_2; the 17th nephropores, each at the bottom of a wide-mouthed nephroporic pit beneath the auricle.

Somite *i* forming the anterior margin of the sucker; the eyes each in an ocular areola; *ii*, *iii*, *iv*, uniannulate, the oculars of *ii* contiguous, of *iii* separated by 4 areolae, of *iv* separated by 6 areolae, and *iv* forming the dorsolateral portions of the margin of the sucker; *v* erratically areolate between the oculars as though 3-annulate, but essentially 2-annulate, $a_1a_2>a_3$, a_1a_2/a_3 continues posterior to the oculars, lacking in the median ventral field, so that a_1a_2 forms the ventrolateral portions of the margin of the sucker, and uniannulate *v* forms the ventral margin; *vi* almost complete 3-annulate, $a_1=a_2$ with the 5th eyes $>a_3$, a_1/a_2 lacking in the mid-ventral field; *vii* 3-annulate, $a_1,a_2<a_3$; *vii* a_3=*viii* a_1; *viii* to *xxiii* 4-annulate (total 16); *viii* $a_1<a_2=b_5=b_6$; *ix* to *xxiii*, the relative lengths of the annuli are not generally assessable with confidence, in the middle of the series some somites show as a_1 slightly $<a_2>b_5=b_6$, as also in *xxiii*, and *xxiii* b_6 complete across the venter; *xxiv* to *xxvii* uniannulate; *xxiv* reduced to a thin ridge across the venter; *xxv* short, excluded from the auricle by the fusion of *xxvi* and *xxvii* forming the simple flange-like auricle with a small obtuse notch.

The dorsum of the posterior sucker with 6 concentric rows of areolae; the venter with a small areolate central area about a quarter of the diameter, the areolae fusing into rows forming muscular ridges subdividing to terminate as some 80 ridges on the margin.

Muscular System (fig. 1. e)

The contracted state prevents description of the body wall muscular envelope and the dorsoventral palisades.

The intersomital dorsoventral musculature in the posterior body somites, the mm. habenae (Richardson 1977) is represented by three pairs of muscular strap-like bands ascending in the paramedian splanchnic chambers medial to the postcaeca, and inserted onto the dorsal body wall in this chamber. These are identifiable as of the A group. The bands are without attachment along their course, and cut at the insertions can be drawn down to the floor of the median splanchnic chamber. The dorsal insertions can only be approximated:

A^1, origin in the posterior half of *xxiii*, the insertion anterior to *xxiii*; A^2, origin at the level of ganglion *xxiv*, insertion in *xxiii*; A^3, origin at the level of ganglion *xxv*, insertion in *xxiv*, *xxv*.

Habenae of the B group were not recognized.

Central Nervous System (fig. 1. e)

The details of the anterior ganglionic mass and ganglia *vii* and *viii* could not be determined; ganglion *xxiii*, spaced from *xxiv*; *xxiv*, *xxv*, *xxvi*, *xxvii*, in intimate contact, ganglion *xxiv* distinctly the larger, and *xxvii* in intimate contact with the posterior ganglionic mass.

Alimentary Tract (fig. 1. f)

The anterior sucker is contracted. The margin is a single fold on all aspects, divided by deep furrows into a transverse anterior portion, longer dorsolateral portions, and a transverse ventral portion, the furrows continuing onto the surface of the chamber of the sucker which is thrown into two tall folds at the inner ends of the dorsolateral portions, and papillate, but the papillae are low, irregular, and do not appear to be permanent.

There is a transverse aperture at the posterior end of the chamber, the aperture leading into a deep annular groove housing the horizontal ventrolateral jaws and a dorsomedian pad, between these a short chamber leading to the restricted entrance to the pharynx.

The jaws are low, compressed, the dental margin nearly straight and about 0.25 mm long, armed with a row of many crowded minute teeth forming a continuous cutting edge.

Posterior to the dorsoventral connectives of the anterior ganglionic masses, the pharynx is thin-walled, narrow, and about 0.25 mm in diameter.

The crop compartments anterior to *xviii* are strongly compressed, the form and caecation not definable; the compartment in *xviii*, distorted, but expanded laterally with caeca median on and wide-based on the compartment; in *xix*, the postcaeca extend from the full length of the side walls of the compartment, both inflated, extended medially so that the intestine is entirely concealed beneath them, thin-walled, and terminating bluntly at about *xxiv*.

The lambertian organs are posterior, in *xxi* and *xxii*, each elongate ovoid, about 0.5 mm long, and connecting subterminally by a duct about 0.75 mm long, to the postcaecum; the duct distinctly longer than the organ.

The intestine is grossly inflated, to such measure that it appears to have short simple lateral caeca, and connects subterminally to the inflated rectum.

Reproductive Systems (fig. 1. d,g)

Genital pores, *xi* b_5/b_6, *xii* b_5/b_6.

Due to contraction, the primary loops of the paired male ducts within the median splanchnic chamber, are compacted, covering the male median region, the ovaries and

ducts of the female system; and the oviducal glandular sac is not longitudinal but transverse in the contiguous halves of *xii*, *xiii*.

The primary loops of the paired male ducts appear to be occupied with sperm ducts. Removal of this compacted mass was necessary to display the terminal end of each duct expanded as a small ejaculatory bulb reducing in diameter to connect independently low on the anterior face of the minute thin-walled male atrium which is entirely ventral to the nerve cord, and amyomeric, micromorphic.

Displacement of the oviducal glandular sac exposed the paired saccular ovaries in the posterior half of *xii*, each continuing as a thin-walled oviduct, the oviducts joining, without the formation of an atrium, to the female median region.

The female median region is formed on a posteriorly directed primary loop, the recurrent limb of the loop narrower than the procurrent limb, the two limbs subequal in length, closely associated along their length and at their junction to the large oviducal glandular sac.

The condition of the specimen obscured the prostate glands. There are no massed albumin glands.

ACKNOWLEDGEMENTS

I express my thanks to Dr. Marian H. Pettibone, the Smithsonian Institute, for the privilege of studying the specimens described above; also to Dr. Á. Soós, the Hungarian Museum of Natural History, for his scholarly reviews of the genera and species in the Hirudinea which have been of major value to me in this and other studies.

The Librarians, C.S.I.R.O., the Australian Museum, the Linnean Society of New South Wales, and other institutions, have assisted me with literature.

The study of this leech was conducted with support from the Australian Research Grants Committee for researches on the zoology of the freshwater-dependent leeches of Australia.

REFERENCES

Blanchard, R., 1897: Hirudinées. In Perrier. TRAITÉ DE ZOOLOGIE, Paris, part 4: 1727-1760.

_____, 1917: Monographie des Hémadipsines (Sangsues terrestres). *Bull. Soc. Pathol. Exot.*, 10: 640-675.

Ingram, D.M., 1957: Some Tasmanian Hirudinea. *Pap. Proc. R. Soc. Tasm.*, 91: 191-232.

Lambert, A.M., 1898: The structure of an Australian land-leech. *Proc. R. Soc. Vict.*, 10: 211-235.

Richardson, L.R., 1971: *Bassianobdella ingrami* sp. nov. from Tasmania (Hirudinoidea: Richardsonianidae). *Pap. Proc. R. Soc. Tasm.*, 105: 113-118.

_____, 1974: *Amicibdella* and *Micobdella* gen. nov. of eastern Australia (Hirudinoidea: Haemadipsidae). *Mem. Qd Mus.*, 17(1): 125-149.

_____, 1975: A contribution to the general zoology of the land-leeches (Hirudinea: Haemadipsoidea Superfam. nov.). *Acta Zool. Hung.*, 21(1-2): 119-152.

_____, 1977: A system of intersomital dorsoventral muscles in the posterior body somites of land-leeches (Hirudinea: Haemadipsoidea). *Aust. Zool.*, 19(2): 233-238.

_____, (in press): On the zoological nature of land-leeches in the Séchelle Islands, and a consequential revision of the status of land-leeches in Madagascar (Hirudinea: Haemadipsoidea). *Rev. Zool. Africaine.*

Soós, Á., 1967: Identification key to the leech (Hirudinoidea) genera of the world, with a catalogue of the species. iv. Family: Haemadipsidae. *Acta Zool. Hung.*, 13(3-4): 417-432.

Papers and Proceedings of the Royal Society of Tasmania, Volume 113, 1979.

(ms. received 9.1.1979)

A PERMIAN FAULT IN NORTH-WESTERN TASMANIA

by Maxwell R. Banks
University of Tasmania

(with one text figure and two plates)

ABSTRACT

BANKS, M.R., 1979 (20 vii): A Permian fault in north-western Tasmania. *Pap. Proc. R. Soc. Tasm.*, 113: 185-191 (incl. two plates). ISSN 0080-4703. Department of Geology, University of Tasmania, Hobart, Tasmania, Australia.

Evidence is advanced to show that faulting occurred during deposition of the Mersey Coal Measures (Early Permian) near Sassafras in north-western Tasmania.

INTRODUCTION

Intrastratal faults in Permian sequences in Tasmania have been known for almost 53 years. David (1926, p.102) figured such faults from Firewood Siding in western Tasmania in a Late Permian carbonaceous sequence and interpreted the faulting and accompanying brecciation as due to glacial over-riding during the Pleistocene, a view rejected by Banks and Ahmad (1959, p.125) in favour of a relationship with normal faulting. Such intrastratal deformation involving faulted competent horizons within carbonaceous sequences has been seen elsewhere in the Permian of Tasmania and figured from coal-measures of other ages and elsewhere (e.g. Stutzer and Noe 1940).

Recent widening of the Bass Highway 3.1 km south of Parramatta Creek and about 9.5 km along the road south-east of Sassafras at 8215 - 466215, has revealed a steep contact between two slightly different sequences of almost horizontal Permian beds with one of the sequences projecting over the contact (fig. 1). There is thus, prima facie evidence of an unconformity or a Permian fault. The beds concerned belong to the Mersey Coal Measures and have been recently shown to contain a microflora belonging to Microfloral Zone 3b of the Permian (Truswell 1978, pp.15-16).

The photographs were taken by Mr. J. Hodgman, Photographic Section, University of Tasmania. I am indebted to Dr. E. Williams, Department of Mines, for helpful criticism.

THE UPTHROWN BLOCK

Strata of the upthrown block are exposed in the gutter and in cuttings on the western side of the road and north of the fault on the eastern side of the road (fig. 1). The sequence commences with a siltstone which weathers pink and is at least 1.4 m thick. This is followed by 0.1 m of coarse friable conglomerate overlain by about 2.25 m of cross-bedded, feldspathic sandstone and then by at least 2 m of carbonaceous siltstone with thin fine-grained sandstone beds. It is this uppermost unit which outcrops against the fault contact on the eastern side of the road. The sequence appears to form part of two fluvial cycles.

In the northern part of the cutting on the eastern side of the road, the carbonaceous siltstone dips north or north-westerly at about 5° (pl. 1, fig. 1). The siltstone passes up along an irregular almost horizontal surface into a leached, clayey zone (pl. 1, fig. 2). The leached zone is in turn overlain by a sequence of thinly-bedded carbonaceous siltstone and fine sandstone which dips at about 5° to the south or south-east and the upper beds of which continue south over and beyond the steep contact. The leached zone probably represents a podsolic soil developed on an unconformity surface.

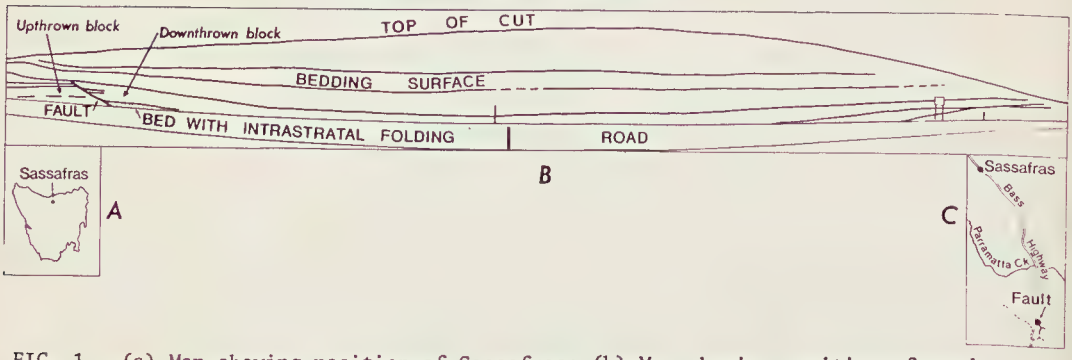


FIG. 1.- (a) Map showing position of Sassafras; (b) Map showing position of road cutting; (c) Sketch of cutting derived from panoramic photographic view; showing fault, intrastratally folded beds and several other beds on both sides of the fault.

The sequence in the upthrown block is sedimentologically akin to the Mersey Coal Measures and bears no resemblance to the marine or estuarine sedimentary rocks of the underlying formation. It was mapped as part of an outcrop of Mersey Coal Measures by Gulline *et al.* (1973) and the evidence supports this assignment.

THE DOWNTHROWN BLOCK

The rocks on the downthrown or south-eastern block form part of two fluvial cycles. At the southern end of the cutting carbonaceous siltstone crops out probably representing deposition in a flood-plain lake. This is overlain by a thin (< 1 m) bed of coarse-grained, cross-bedded quartz sandstone (pl. 1, fig. 3), a channel and point bar deposit, which is overlain by carbonaceous siltstone 1.5 m thick in places but dying out towards the southern end of the cutting. The siltstone, which may represent a pool in a swale or an ox-bow lake, is overlain by thinly interbedded beds of carbonaceous siltstone and fine-grained ripple-marked siliceous sandstone with fine scale cross-bedding representing flood plain and levée bank deposits. The interbedded sequence is about 5 m thick and from half way up this sequence or a little higher the specimens dated by Truswell (1978) were derived.

Close to the fault the sequence dips shallowly south-east but the dip reverses about 30 m south-east of the fault and becomes almost horizontal with perhaps a slight component to the north (fig. 1c).

Within the sequence south of the fault are two beds with intrastratal folding, the lower of which outcrops against the fault at gutter level and is carried by the dip below the ground surface 12 m from the contact. This lower bed re-emerges 58 m from the contact beyond which it continues, broken in outcrop by material slipping down from higher up the cut, to a point 178 m from the contact where the rocks in the cut become indistinct. The upper intrastratally folded bed crops out for only a few metres south of the contact.

The lower intrastratally folded bed is at the base of the sequence of interbedded carbonaceous siltstone and fine sandstone, i.e. at the base of the levée bank and flood plain sequence. It is about one metre thick but thins out completely in some places. It consists of a series of lobes, some disconnected, some overriding other lobes from the north (pl. 1, fig. 3; pl. 2, fig. 1). The lobes are consistently rounded to the south and thinned or pointed and disconnected to the north. The lobes have axial surfaces which are almost parallel to the bedding in many cases but some make an angle of up to 30° with the bedding. The axial surfaces dip towards the fault in some places,

away from it in others. The trend of the one fold lobe exposed in the gutter is 128° and this is also the trend of the axis measured on one excavated fold close to the fault. The fold hinge dips to 128° at about 2°. No sign of erosion along the top surface of the intrastratally convoluted bed was detected but the contact was by no means clearly exposed. The folds have a geometry which best fits a slump origin and it is interesting to note that Conybeare and Crook (1968, pp.38-9) comment on the occurrence of slumps produced by hydroplastic flow resulting from collapse of alluvial sediments particularly of the upper parts of point bar deposits. In the bed most of the deformation seems to have been by folding and to most closely match "slurry slump bedding" (Conybeare and Crook 1968, p.39, Plate 38). Some of the beds slightly above the lower intrastratally folded bed show minor deformation by contemporaneous faulting (pl. 2, fig. 2).

The beds of the downthrown block are sedimentologically like those of the upthrown block (but with some differences in thicknesses and succession) and thus also like the Mersey Coal Measures. In fact thin (a few mm) seams of vitrinite may be found not far above the lower intrastratally folded bed. In addition there is palynological evidence (Truswell 1978) that this sequence contains the same microflora as the Mersey Coal Measures.

THE FAULT ZONE

When viewed approximately along strike (pl. 1, fig. 1) the fault is seen to be a steep, slightly irregular contact. It is difficult to measure the strike accurately, but it is approximately 33°. The beds on the downthrown block dip slightly more steeply away from the fault near it than they do further away suggesting a drag dip on a normal fault. In the lower part of the cutting there is a fault zone several tens of centimetres wide occupied by dipping beds of carbonaceous siltstone like that on the upthrown side, the dip near the gutter being slightly steeper than, but in the same direction as, the dip of the beds in the downthrown block (pl. 2, fig. 3). Higher in the fault horse, the beds of siltstone are horizontal or dip gently north. The fault does not break the higher beds in the sequence which continue over it with a slight change of dip from downthrown to upthrown block. No precise information is available on the throw of the fault but it is more than 1.5 m but less than the stratigraphic thickness of the Mersey Coal Measures (approximately 35 m).

The contact has been interpreted as a fault because of the discontinuity, the change in dip on opposite sides of the contact, the presence of a fault horse with beds of a third dip and the angular unconformity on the upthrown block. One or more of these criteria could be equally explained by postulating that the contact was an unconformity, a steep, eroded channel bank or the failure surface of a landslide such as might occur in a steep, ox-bow bank but none of these possibilities satisfies all criteria as does the fault solution. It is therefore concluded that the contact is a fault.

Mild tectonic activity has been postulated to have affected Tasmania during the Permian Period on the basis of change in isopach patterns (Banks 1962, p.215) and may well have been the cause of sharp changes in sediment type (Cascades Group to Malbina Formation in the Mt. Nassau area, Banks and Read 1962, p.23) associated with absence of a faunal assemblage zone (Clarke and Banks 1975, fig. 33.4, p.460) and of other paraconformities (contact between Faunal Zones 2 and 5 in the Cygnet area - Clarke and Banks 1975, pp.460-1), but no evidence in the form of intra-Permian angular unconformities has been advanced. It is possible that the fault described here, as well as the evidence of angular unconformity and exposure to weathering on the upthrown block, may provide such evidence. However, before this exposure can be taken as evidence of a stress operating at the time in the crust beneath Tasmania and thus be thought of as tectonic in a proper sense, a superficial origin would have to be

eliminated. This cannot be done on the evidence available and a superficial origin is even rather likely.

A superficial origin is suggested by similar occurrences in coal measures elsewhere as noted earlier and the common occurrence of growth faults in deltaic successions elsewhere (see Edwards 1976 for a recently described example and for references to literature on growth faults). Like growth faults this structure occurs within a broadly deltaic environment (the Mersey Coal Measures rest on estuarine deposits immediately and marine deposits at greater depth and were flooded in many places by a transgression of the sea), the delta building out south-eastwards from the Mersey area into a shallow sea. Like growth faults this structure throws down towards the sea, the sedimentary sequence is thicker on the downthrown side and, as with many growth faults, one or other of the blocks is tilted. However, this fault cannot be demonstrated to be a growth fault as corresponding beds on the upthrown and downthrown blocks are not available for measurement and comparison of thickness. The throw, although unknown, (1.5 to 35 m) is rather smaller than those quoted for most growth faults. However, it seems likely that the hypotheses offered for the origin of growth faults could also apply in this case e.g. differential compaction (Carver 1968) and regional gravity creep into the deeper parts of a basin (Cloos 1968), especially in view of the presence of unstable, hydroplastic carbonaceous silts and likely presence of these at shallow depth beneath the fault. Local instability may have been induced by earth tremors due to movement on deep-seated or distant faults.

Thus for the time being the fault may be recorded but its origin must remain unclear. A tectonic origin is possible but not required by the evidence. A superficial origin of the stress producing the fault is consistent with and more likely than a deep-seated origin on the evidence.

SYNTHESIS

During the deposition of Microfloral Zone 3b in the Early Permian Epoch the Sassafras area was part of the flood plain of a high sinuosity meandering stream as shown by the nature of the sedimentary rocks and the succession (Allen 1965, pp.165-6). Meander migration led to deposition of several cycles commencing with channel gravels and progressing through thin point-bar sands to swale-fill or ox-bow deposits of carbonaceous siltstone followed in one cycle at least by levée bank and flood plain fine sands and carbonaceous silts.

At some stage during meander migration a normal fault developed with a trend of 33° and a downthrow to the south-east. The upthrown block was tilted down to the north-west, eroded and on it probably developed a podsolic soil. Later meander migrations caused deposition of levée bank and flood plain sediments over the upthrown block. At several stages in the deposition of the levée bank and flood plain deposits bank collapse led to formation of slurry slumps along axes trending about 128° and down towards the south-west. Presumably 128° was approximately the trend of the bank and adjacent channel.

REFERENCES

Allen, J.R.L., 1965: A review of the origin and characteristics of Recent alluvial sediments. *Sedimentology*, 5(2): 89-191.

Banks, M.R., 1962: Permian. In Spry, A.H. and Banks, M.R. (Eds): GEOLOGY OF TASMANIA. *J. geol. Soc. Aust.*, 9(2): 189-215.

_____ and Ahmad, N., 1959: Notes of the Cainozoic history of western Tasmania - "Malanna Glaciation". *Pap. Proc. R. Soc. Tasm.*, 93: 117-127.

_____ and Read, D.E., 1962: The Malbina Siltstone and Sandstone. *Pap. Proc. R. Soc. Tasm.*, 96: 19-32.

Carver, R.E., 1968: Differential Compaction as a cause of regional contemporaneous faults. *Bull. A.A.P.G.*, 52(3): 414-419.

Clarke, M.J. and Banks, M.R., 1975: The stratigraphy of the lower (Permo-Carboniferous) parts of the Parmeener Super-group, Tasmania. In Campbell, K.S.W. (Ed.): GONDWANA GEOLOGY, 453-467. ANU Press Canberra.

Cloos, E., 1968: Experimental analysis of Gulf Coast fracture patterns. *Bull. A.A.P.G.*, 52(3): 420-444.

Conybeare, C.E.B. and Crook, K.A.W., 1968: Manual of Sedimentary Structures. *Bur. Miner. Resour. Aust. Bull.*, 102.

David, T.W.E., 1926: Pleistocene glaciation near Strahan, Tasmania. *A.N.Z.A.A.S.*, XVII (1924): 91-103.

Edwards, M.B., 1976: Growth faults in Upper Triassic deltaic sediments, Svalbard. *Bull. A.A.P.G.*, 60(3): 341-355.

Gulline, A.B., Bravo, A.P. and Naqvi, I.H., 1973: Frankford. Geological atlas 1 mile series. Zone 7 sheet 38 Dept. of Mines, Tasmania.

Kemp, E.M., Balme, B.E., Helby, R.J., Kyle, R.A., Playford, P.E., Price, P.L., 1977: Carboniferous and Permian palynostratigraphy in Australia and Antarctica: a review. *B.M.R. J. Aust. Geol. Geophys.*, 2: 177-208.

Stutzer, O. and Noe, A.C., 1940: GEOLOGY OF COAL. Univ. of Chicago Press: 374-5.

Truswell, E.M., 1978: Palynology of the Permo-Carboniferous in Tasmania: an interim report. *Geol. Surv. Tasm. Bull.*, 56.

PLATE EXPLANATIONS

PLATE 1

Figure 1

A photograph looking north-north-east along the contact. Lower bed with intrastratal folding at lower right.

Figure 2

A photograph of the upthrown block showing the leached zone and the angular conformity.

Figure 3

Lower intrastratally folded bed resting almost directly on conglomerate layer (just below scale which is just over 0.4 m long).

PLATE 2

Figure 1

Lower intrastrally folded bed close to fault. Arrow indicates fold dug to reveal axial trend. View is taken looking east. Scale approximately 0.4 m long.

Figure 2

View taken looking east of lower intrastratally folded bed where it rises into the cutting about 60 m south of the fault. Scale approx. 0.4 m.

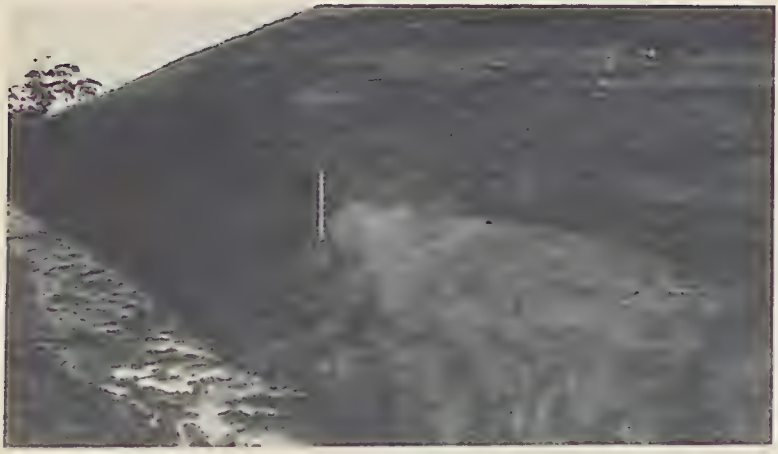
Figure 3

Fine sandstone - carbonaceous siltstone sequence with contemporary minor normal faulting. About 60 m south of fault; scale approx. 0.4 m.

Figure 4

A view of the fault zone showing the "fault horse" with beds dipping south-east. Scale 1.75 m long.

Permian fault in Tasmania

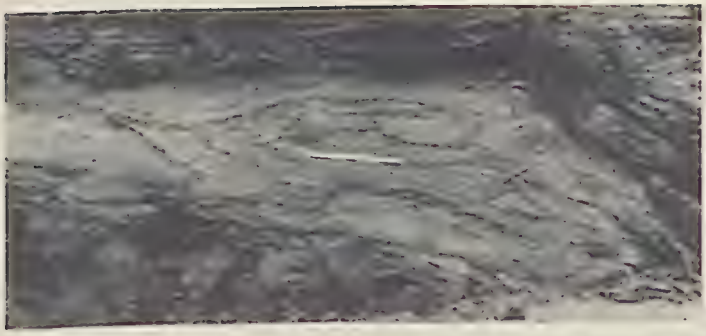


1

2

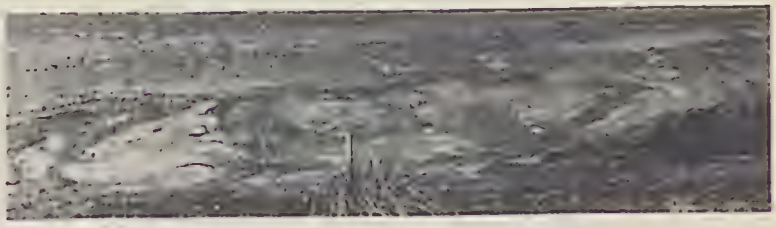
3

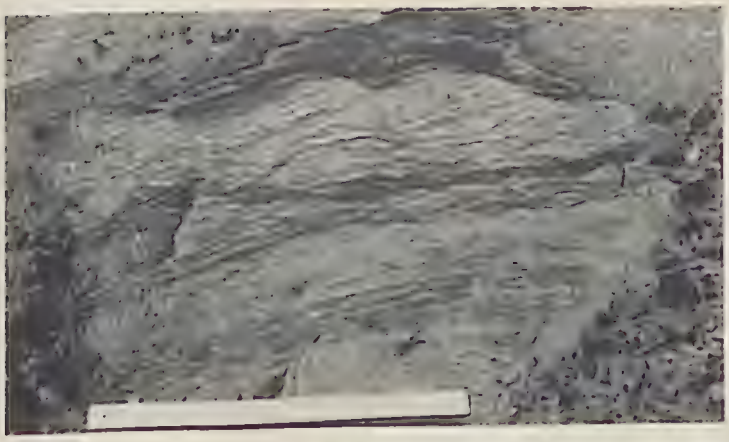
PLATE 1



1

2





3

4

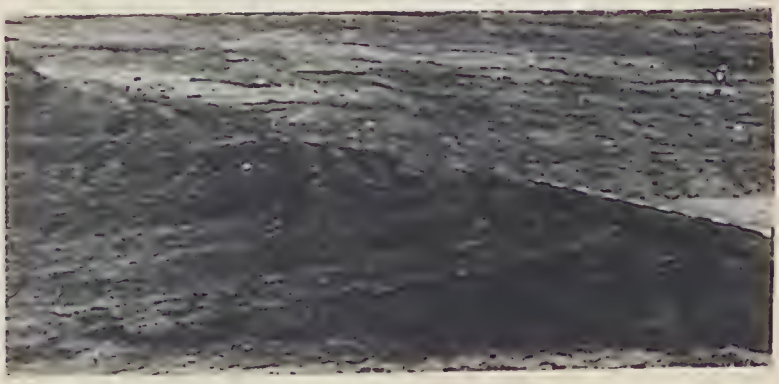


PLATE 2

PAPERS AND PROCEEDINGS OF

The Royal Society of Tasmania

NATIONAL MUSEUM
18 AUG 1980
OF VICTORIA

Edited by M. R. Banks and Published by the Society

Hobart, Tasmania

May 1980

Volume 114

T. J. Hughes, Government Printer

ISSN — 0080-4703

COUNCIL AND OFFICE BEARERS

Patron

Her Majesty the Queen

President

His Excellency the Governor of Tasmania
Sir Stanley Burbury

Vice-Presidents

Dr E.A. Colhoun
Mr R.J. Downie

Council

Mr A.J. Dartnall
Mr G.E. Hale
Mr E.H. Norton
Mr K.E.J. Robinson
Mr J.D. Thomson
Mr S.J. Thrower
Mr R.E. Ward
Mr P.G. Webb

Honorary Secretary

Mr D.R. Gregg

Honorary Treasurer

Mr T.A.H. Knight

Honorary Auditor

Mr D.B. Churchill

Honorary Editor

Dr M.R. Banks

NATIONAL MUSEUM
18 AUG 1980
OF VICTORIA

PAPERS AND PROCEEDINGS OF THE ROYAL SOCIETY OF TASMANIA

VOLUME 114

CONTENTS

	Page
Annual Report and Balance Sheet	v
KIRKPATRICK, J.B. – Tasmanian high mountain vegetation I - A reconnaissance survey of the Eastern Arthur Range and Mount Picton.	1
BROWN, M.J. – The vegetation of the Mt Cameron West aboriginal site.	21
CORBETT, Keith D. – A record of aboriginal implement sites in the Queenstown area, Tasmania.	35
MURRAY, Peter – Demystification of the Mersey Bluff markings.	41
COCKER, Joshua D. – Regional geology of the southern Furneaux Group.	49
LENNOX, P.G. – Geology of the Bluff Hill Point region.	69
GRIFFIN, B.J. – Erosion and rabbits on Macquarie Island: some comments.	81
SCOTT, E.O.G. – Observations on some Tasmanian fishes: Part XXVI.	85
DZIEWA, Thomas John. – Early Triassic osteichthyans from the Knocklofty Formation of Tasmania.	145
FORD, Ramsay J. and KEMP, Noel R. – Petterdite re-analysed.	161
CORBETT, Keith D. – An Early Miocene flathead. (Pisces Platycephalidae) from Wynyard, Tasmania.	165
SUTHERLAND, F.L. – Aquagene volcanism in the Tasmanian Tertiary, in relation to coastal seas and river systems.	177
STAIT, Bryan and LAURIE, John – Lithostratigraphy and biostratigraphy of the Florentine Valley Formation in the Tim Shea area, southwest Tasmania.	201
ROSE, R.W. – A survey of birds of the Lower Gordon region, southwestern Tasmania.	209
JAGO, J.B. – Late Middle Cambrian fossils from Beaconsfield, Tasmania.	219
ALLEN, Jim and JONES, Rhys – Oyster Cove: Archaeological traces of the last Tasmanians and notes on the criteria for the authentication of flaked glass artefacts	225

18 AUG 1980
OF VICTORIA

ROYAL SOCIETY OF TASMANIA

ANNUAL REPORT FOR THE YEAR 1979

The Council has the honour to present to members the following report on the activities of the Society during the year.

COUNCIL AND OFFICE BEARERS

Patron
Her Majesty the Queen

President
His Excellency the Governor of Tasmania
Sir Stanley Burbury

Vice-Presidents

Mr A. Dartnall
Mr G.E. Hale
Mr E.H. Norton
Mr K.E.J. Robinson
Mr J.D. Thomson
Mr S.J. Thrower
Mr R.E. Ward
Mr P.G. Webb

Honorary Secretary
Mr D.R. Gregg

Honorary Treasurer
Mr T.A.H. Knight

Honorary Auditor
Mr D.B. Churchill

Honorary Editor
Dr M.R. Banks

PRESIDENT

Sir Stanley Burbury took the Chair, as President of the Society, at the Annual General Meeting in March. He also took the Chair at the General Meeting of the Northern Branch in August.

HONORARY LIFE MEMBER

Mr G.E.A. Hale was elected an Honorary Life Member in recognition of the outstanding service he has given to the Society particularly as Honorary Treasurer from 1954 to 1977.

ANNUAL MEETING

At the Annual Meeting on 6 March, Mr G.E.A. Hale retired as Vice-President, and Mr R.J. Downie and Mr A.R. Neilson as Members of the Council. The following were elected -

Vice President	Mr R.J. Downie
Members of Council	Mr A.J. Dartnall
	Mr G.E.A. Hale
Honorary Secretary	Mr D.R. Gregg
Honorary Treasurer	Mr T.A.H. Knight
Honorary Auditor	Mr D.B. Churchill

REVIEW OF RULES

The committee set up in 1978 to carry out an overall review of the Society's function and to make recommendations on possible changes to the Rules has reported to the Council and the report is under consideration.

BICENTENNIAL OF FOUNDATION OF AUSTRALIA

The Council has discussed ways of appropriately marking the bicentennial of the European settlement of Australia in 1788.

LECTURES

The following lectures were given at General Meetings during the year -

March	'Alpine Landforms of the Colorado Rocky Mountains'	Professor Nelson Caine University of Colorado
April	'The Greek Arrival in Tasmania Architecture'	Dr E.V. Ratcliff Launceston
May	'Wildlife Conservation'	Dr I.B. Eberhard National Parks and Wildlife Service
June	'Requiem for the gum trees? Some problems old and new'	Dr Frank Podger CSIRO, Hobart
July	'Solar Heating'	Mr R.G. Sutton TCAE, Mt Nelson
August	'Tasmanian Shell Fisheries - lessons from the past and planning for the future'	Mr A.J. Harrison Tasmanian Fisheries Development Authority
September	'The City in an Era of Restricted Car Usage : potential responses to future energy shortages'	Dr Trevor Lee University of Tasmania
October	'Probing the interior of the inner planets'	Professor D. Green University of Tasmania
November	'Bureaucratic Reform - a bureaucrat's perspective'	Mr N.C.K. Evers Director of Energy

LIBRARY

The thorough reorganisation of the library, its procedures and records, which Mrs D.A. Lewis was charged to carry out when she was appointed Librarian in July 1977, continued throughout 1979 and was completed in all important respects by the end of the year when Mrs Lewis retired. During the year work continued on the re-arrangement and tidying up of the serials collection, which had been commenced in 1978, and this large undertaking was completed by August. The review of the Library's exchange arrangement was also completed and all records brought up-to-date.

At its February meeting Council agreed to reduce the very substantial stock of back issues of the *Papers and Proceedings* stored in the Library. It was decided that for all volumes up to and including 1969 a maximum stock of 50 copies of each should be

retained and that all surplus copies should be made available to members at 20¢ per issue. The sale was conducted from March to mid-May and proved very successful : takings exceeded $1200 with many full priced publications being sold in addition to the bargain issues, and a considerable amount of much needed shelf space was freed in the Library.

Throughout the year the Library was given special priority in access to the University Library's bindery with the result that almost double the normal annual quota of binding was accepted. A total of 1194 volumes were bound.

In July work commenced on a revision of the Library's catalogue of serials holdings and this was completed by the end of November. The new catalogue, in addition to being a complete and up-to-date record of holdings, is easier to use than its predecessor because its entries are simpler. Future plans are for these records to be entered into the University Library's catalogue data base and for a separate microfiche listing of the Society's serials holdings to be produced.

Three additional pieces of equipment were provided early in the year. These were a wooden display rack for displaying current issues of journals, a microfiche reader primarily for use of the University Library's microfiche catalogue and a photocopying machine. The latter item has proved less useful than anticipated because of poor mechanical performance and it is planned to replace it with a new machine in 1980.

During the year 395 visits by members of the Society, University staff and students, and other users were recorded in the Register of Users. The Library supplied 198 items in response to interlibrary loan requests in the course of the year.

The Council is grateful to Mrs Lewis for her dedicated service to the Society and, in particular, for her reorganisation of the Library.

PUBLICATIONS

Volume 113 of the *Papers and Proceedings* was published in July 1979. It contained 15 papers by 16 authors and totalled 191 pages. Format was changed slightly to include a bibliographic identification ("biblid") with the abstract of each paper.

FINANCES

Despite rising costs of producing the *Papers and Proceedings*, the Society's contribution has been reduced in the current year by $3,568 as a result of a smaller volume and the increased subsidies received from the Tasmanian Government and the University of Tasmania.

Recovery of outstanding subscriptions has helped to increase revenue by $290 and this, together with the $1,200 resulting from the sale of publications, has increased bank holdings by $4,406 despite a generally lower return from investments.

It is disappointing to have to report that $87 in cash has been mislaid and has not been found after an extensive search. Procedures have been tightened to prevent a similar occurrence in the future.

MEMBERSHIP

During the year the membership was 506, an increase of 3. The membership is made up as follows -

	Northern Branch	Total
Honorary Life Members	2	7
Life Members	8	37
Ordinary Members receiving the *Papers and Proceedings*	69	266
Ordinary Members not receiving the *Papers and Proceedings*	94	173
Associate Members	15	23
	188	506

NORTHERN BRANCH

The Northern Branch of the Society based in Launceston elected the following Council:

Chairman	Mr H.S. Payne
Vice-Chairman	Dr D.F. Smith
Honorary Secretary	Mr P.G. Webb
Honorary Treasurer	Mr J.D.A. Abey
Honorary Auditor	Mr H.C.A. Pitt
Council Members	Mr P.F.J. Leonard (elected 1978)
	Mr D. Walter (elected 1978)
	Mrs N.I. Hardy Wilson (elected 1978)
	Mr B. Pike
	Mrs B. Davies

The Council co-opted the following members:

Mr K.E.J. Robinson
Dr E.V.R. Ratcliffe

The Branch Council met four times; it was represented on the Society's Council by Messrs R. Ward and P.G. Webb, and two members of Council served on the Committee set up to review the Rules.

The following lectures were given:

March	'The Life and Ballads of A.B. Paterson'	Mr R. Ward
April	'Impressions of a visit to the People's Republic of China'	Mrs M. Smith & Mr P.G. Webb
May	'The Authority of Politics in Today's Society'	Senator J.O. Watson
June	'The Authority of Religion in Today's Society	Mr M.H. Todd
July	'The Authority of Sport in Today's Society	Mr R.S. Collins
August	'The Authority of Science in Today's Society'	Dr C. O'Flaherty

The May to August lectures comprised the third series by staff of the Tasmanian College of Advanced Education, Newnham.

September	'The World of Birds - a Scientific and Fun Study'	Mr David Henderson
October	'Indonesia'	Mr D. Walter

November	'The Work of the Museum, and its Role in the Community'	Messrs C.B. Tassell, M. Clark and D. Woods
December	Members Night -	
	'Impressions of Israel'	Mr G.H. Stancombe
	'The Uniqueness of the Seychelles'	Dr D.F. Smith

Excursions visited the Blue Tier - St Helens area at Easter, and Mathinna on 3 November.

The Branch assisted the Tasmanian Historical Research Association in presenting the 1979 Eldershaw Memorial Lecture by Professor K.S. Inglis.

COUNCIL MEETINGS

The Council met four times during the year with Mr R.E. Ward and Mr P.G. Webb representing the Northern Branch on the Council.

NOMINEES TO OTHER BODIES

The Council re-elected Dr M.R. Banks and Dr D. Martin to the Board of Trustees of the Tasmanian Museum and Art Gallery. They report on the year's activities:

> The building at 40 Macquarie Street, built in 1808-10, has been renovated with funds provided by the Tasmanian Government and was opened by the Premier on 30 November 1979. It houses the administration, education, art and art conservation sections. The building is the first to be occupied of those purchased from the Commonwealth in 1977. Funds have been made available in the 1979 Budget to enable the renovations to continue and work will soon start on the ground floor of the Queen's Warehouse, built about 1869 behind the Macquarie Street Store.
>
> The Trustees welcomed the decision of the Tasmanian Government to purchase the Zeehan Post Office from the Commonwealth and to make the first floor available for extensions to the West Coast Pioneers' Memorial Museum. The building will make a useful and appropriate addition to the display area of the Museum. The Trustees have decided to appoint a curator to take charge of the Museum at Zeehan.
>
> During the 1978-79 financial year visitors to the Tasmanian Museum and Art Gallery totalled 103,000. Visitors to the West Coast Pioneers' Memorial Museum were estimated at 124,000.
>
> Dr Banks was re-elected Chairman of Trustees. There have been a number of changes in membership of the Board. Mr G.F. Davies resigned in February 1979 having served as a Trustee since 1957. Mr G.C. Cramp retired at the end of 1979 having served since 1955. Mr L.W. Miller resigned in June 1978 having served since 1951. Dr D.F. Smith served as a Trustee from August 1978 till October 1979.

Dr Jocelyn E.S. Townrow continued as the Council's nominee on the Board of Trustees of the Royal Tasmanian Botanic Gardens. She reports on the year's activities:

> Continued upgrading of the Gardens over the past year has excited much public comment, particularly appreciation of the floral displays in the grounds and

the Conservatory. Completed projects include the gazebo and surrounding rockeries beside the playground, installation of the W.J. Syme Memorial Fountain, interior landscaping of the Fuschia House, and planting of an extensive herb garden. A shelter and viewing platform designed and donated by the Department of Environmental Design, Tasmanian College of Advanced Education, in collaboration with the Timber Promotion Board to promote Tasmanian timbers in reusable form will shortly appear in the northern Eucalypt section and will enhance and support present efforts to develop this area for native and endemic species.

Mr Brian Lumb, who was appointed 31 October as Assistant Superintendent, has taken over the field administration of the Gardens, freeing the Superintendent, Mr A.P. May, to concentrate on administration and advisory work.

The Gardens Museum was opened by the Minister, the Hon T.G. Aulich, on 6 September with four of the rooms of the Superintendent's Cottage devoted to special displays including a Gardens historical section, endemic and native species, 100 native and introduced grasses, Tasmanian orchids, Huon Pine section with dated growth rings, vases and bowls of turned Tasmanian timbers, aromatic oils from Tasmanian trees, a philatelic display with a botanical theme, and a propagating room and associated glasshouse for instruction of school children. About 25 members of the general public have volunteered as Friends of the Gardens and are rostered to assist Mr Marcus Hurburgh, the Education and Information Officer, in the daily supervision of the Museum.

The number of visitors to the Gardens was 157,000, an increase of approximately 6% over last year. Tourist buses now stay at least one hour at the Gardens reflecting the increased public interest in the general displays and increased educational facilities.

The State Government grant of $500,000 is once again insufficient to allow rebuilding of the almost derelict depot area or replacement of No 4 glasshouse which is in a similarly dangerous condition.

ACKNOWLEDGEMENTS

The Council is grateful for help generously given by many individuals and organisations. In particular, the lecturers, the Government of Tasmania, the University of Tasmania, the Tasmanian Museum and Art Gallery, and the Queen Victoria Museum and Art Gallery are specially thanked for their help and cooperation.

E.A. COLHOUN
Senior Vice-President

D.R. GREGG
Honorary Secretary

ROYAL SOCIETY OF TASMANIA

Balance Sheet as at 31 December 1979

1978						1979
60 676.30	Accumulated Funds		53 051.50	33.00	Cash on Hand	33.00
36.00	Subscriptions in advance		65.00		Cash at bank:	
	Trust Funds:			1 103.65	- General Account	4 690.74
1 273.09	-Clive Lord Memorial Fund	1 315.39		1 402.40	- Papers & Proceedings Account	2 224.70
2 007.97	-A.N. Lewis Memorial Fund	2 102.90		803.99	- Clive Lord Memorial Fund	658.66
869.83	-Morton Allport Memorial	925.07		907.97	- A.N. Lewis Memorial Fund	1 050.17
371.27	-A.A. Clark Bequest	391.27		869.00	Mortgage loan	860.00
2 494.39	-Joseph Milligan Bequest	2 622.80			Commonwealth Treasury Bonds	
1 276.23	-R.M. Johnston Memorial Fd.	1 356.44		9 840.00	& Inscribed Stock (at cost)	10 440.00
552.89	-Henry Oliver Bequest	590.12		7 000	Interest Bearing Deposits	7 000.00
1 379.57	-W.H. Hudspeth Memorial	1 436.73		15 000.00	Library (at valuation for insce)	15 000.00
1 477.07	-Life Membership Fund	2 176.70	12 917.42	35 463.60	Publications (at selling prices)	24 076.65
$72 414.61			$66 033.92	$72 414.61		$66 033.92

GENERAL ACCOUNT TO 31 DECEMBER 1979

Balance brought forward		1 103.65	Stationery	176.16
Subscriptions -			Insurance	114.65
1 @ $200	200.00		Attendants' fees	394.11
237 @ $ 12	2 844.00		Presentations	22.50
150 @ $ 8	1 200.00		Secretarial fees	200.00
18 @ $ 5	90.00		Northern Branch	700.00
Other years	561.00	4 895.00	Petty Cash	60.00
Interest		888.69	Management fee University	1 450.00
Sales of publications &			Post box rental	102.00
Papers & Proceedings		3 165.82	Postage and freight	910.71
Government Grant		1 450.00	Investments	400.00
Rent		213.60	Photocopying	150.95
Miscellaneous		8.00	Subscriptions	694.39
University subsidy		1 500.00	Printing of *Papers & Proceedings* & Publications	3 054.35
		13 224.76	Refund	4.00
Deduct Banking Deficiency		87.00	Bank fees	13.20
				8 447.02
			Balance carried forward	4 690.74
		$13 137.76		$13 137.76

PAPERS AND PROCEEDINGS ACCOUNT TO 31 DECEMBER 1979

Balance brought forward	1 402.40		
Interest	822.30	Balance carried forward	2 224.70
	$2 224.70		$2 224.70

YEAR ENDED 31 DECEMBER 1979

ACCUMULATION ACCOUNT

Balance 1 January 1979			60 676.30
Deduct	Net decrease in valuation of publications for sale	11 386.95	
	Net increase in advance subscriptions	29.00	
	Net transfers to Trust Funds - current year	815.11	
	- Life Fund - 1978 adjustment	400.00	12 631.06
			48 045.24
Add	Increase in cash at banks	4 406.26	
	Increase in investments	600.00	5 006.26
Balance 31 December 1979			$53 051.50

Papers and Proceedings of the Royal Society of Tasmania, Volume 114, 1980.

(ms. received 11.4.1979)

TASMANIAN HIGH MOUNTAIN VEGETATION I - A RECONNAISSANCE SURVEY OF THE EASTERN ARTHUR RANGE AND MOUNT PICTON

by J.B. Kirkpatrick
Geography Department, University of Tasmania

(with three tables, four text figures and two plates)

ABSTRACT

KIRKPATRICK, J.B., 1980 (31 v): Tasmanian high mountain vegetation I - a reconnaissance survey of the Eastern Arthur Range and Mt Picton. *Pap. Proc. R. Soc. Tasm.*, 114: 1-20 (incl. 2 plates) ISSN 0080-4703. Department of Geography, University of Tasmania, Hobart, Tasmania, Australia.

The high mountain vegetation of Mt Picton and the Eastern Arthur Range varies structurally from closed-forest to low closed-heath and is composed of at least two associations, and eight sub-associations, containing 128 higher plant species of which 76 occur on both mountains. Only one and four respectively of extremely fire sensitive species occur on Mt Picton and the Eastern Arthur Range, the former having been burnt recently and the latter probably centuries ago. Differences in fire history, soils, geomorphology and precipitation may account for the observed differences in the range and composition of the plant communities and floras of the two mountains. The flora of Mt Picton is shown to generally have more species in common with mountains with relatively fertile soils, while that of the Eastern Arthur Range has a general more species in common with mountains where the soils are predominantly extremely poor.

INTRODUCTION

Although Tasmania constitutes less than 0.9 per cent of the total area of the Commonwealth of Australia it contains more than 50 per cent of the nation's area of high mountains as defined by Costin (1973). Tasmanian alpine vegetation is characteristically dominated by shrubs, in contrast to the predominantly herbaceous vegetation found in the high country of Australia (Costin 1973) and New Zealand (Cockayne 1928). Approximately 50 per cent of the vascular plant species found in the plateaus and peaks of the mountains of Tasmania are Tasmanian endemics, and many more species are found in Tasmania and New Zealand but are absent from the Australian mainland. The literature contains only a few accounts of the Tasmanian high mountain plant communities, their local distribution patterns and their relationships to environmental variables. The vegetation of Mt Wellington (Martin 1940), the Central Plateau (Jackson 1973), Mt Field and Mt Rufus (Davies 1978), the West Coast Range (Kirkpatrick 1977) and Cradle Mountain (Sutton 1929) has been thus described. This paper describes the high mountain vegetation of Mt Picton and the Eastern Arthur Range in the heart of the wilderness area of south-western Tasmania (figure 1) and discusses the environmental relationships of the plant communities, their floristic relationships and management problems.

The Eastern Arthur Range extends for approximately 8 km from Luckmans Lead in the north to Lake Geeves in the south (figure 2). Only a few peaks exceed 1000 m, the main ridge varying from 910 m to approximately 1140 m in altitude. The range has been subject to glacial erosion in the past and is subject to periglacial and fluvial erosion at present. Glaciers have carved deep cirque basins to the north, east and south of the Precambrian quartzite range leaving the higher jagged peaks uncovered, but moved across the divide in places such as Goon Moor and Thwaites Plateau where the landscape is smoothed. The soils are skeletal on the steeper slopes and shallow, acid peats on the gentler slopes. The mean annual precipitation and its seasonal distribution pattern are unknown, but are likely to approximate those experienced at Strathgordon (table 1). Short periods of snow cover can occur at any time of the year, yet the range may be bare of snow for periods in the coldest months. The prevailing westerly

High Mountain Vegetation - Eastern Arthur Range and Mount Picton

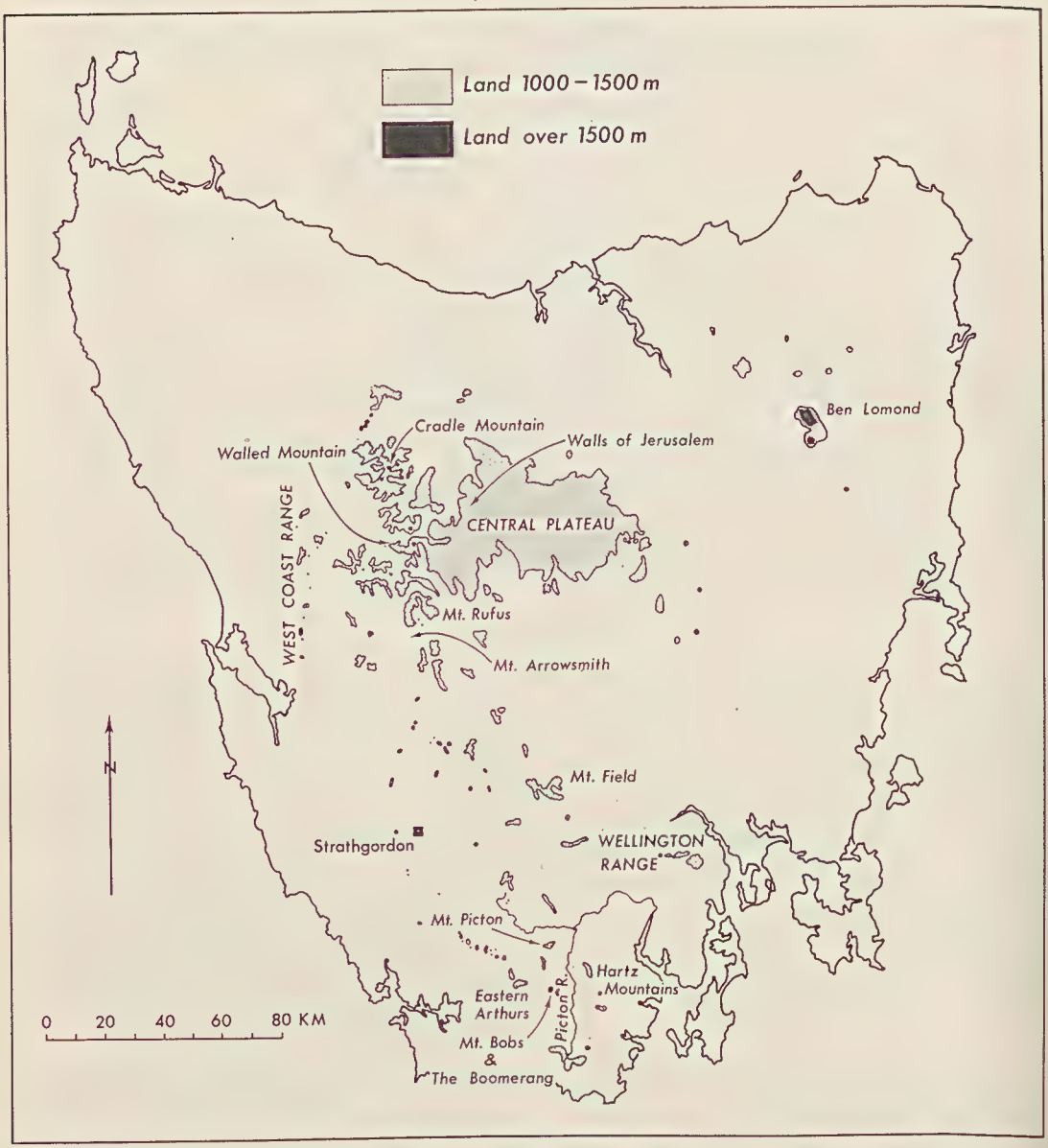


FIG.1- Locations mentioned in the text.

winds are sufficiently strong to have created, in combination with low temperatures and ice, wind stripes in the vegetation of some of the moors and distinct asymmetry in exposed shrubs.

The climate of Mt Picton is probably similar to that of the Eastern Arthur Range except that precipitation may be less as a result of the screening effect of windward ranges. Mt Picton consists of a Jurassic dolerite arete overlying a Permian mudstone shelf. The peak of Mt Picton attains 1310 m and the shelf varies between 850 m and 975 m in altitude. The shelf is partly overlain by moraine derived from dolerite. The southern slope of the mountain (not described in this paper) is bounded by several moraine-dammed lakes. The soils vary from acid peats in the flatter areas to alpine humus and skeletal soils on the steep dolerite slopes.

Nomenclature follows Curtis (1963, 1967) and Curtis and Morris (1975) for gymnosperms and dicotyledons, (Willis (1970) for monocotyledons, and Wakefield (1975) for pteridophytes except where authorities are given (Appendix). Terminology describing the structural forms of vegetation follows Specht (1970) except that his closed-heath has been divided into closed-heath (0.2-2.0 m tall) and low closed-heath (less than 0.2 m tall).

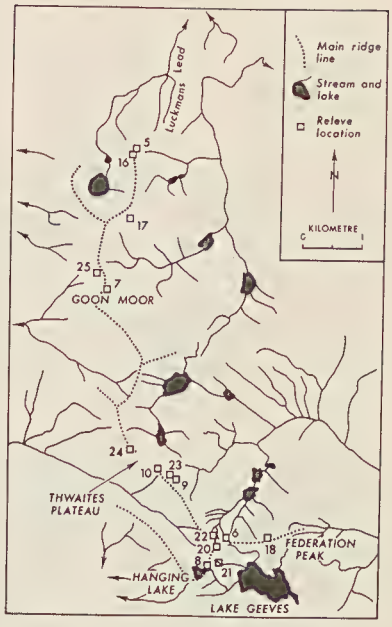


FIG.2.- The location of releves in the Eastern Arthur Range .

METHODS

Lists were made of the vascular plants present in twenty four releves of variable size but within relatively homogeneous vegetation, during January 1976. Structural characteristics, dominance and relationships to other structural-dominance types and environmental variables were also noted. The lists included almost all the species in the local area of the particular structural-dominance type, searching being continued until no further species were found or until the vegetation type changed. Releve locations were chosen to encompass as much of the range of structural-dominance types as was possible in the time available for the work and did encompass all high altitude vegetation types dominated by shrubs or herbs occupying areas greater than 10 ha as well as some types covering a lesser area and some types dominated by trees.

The releve species presence and absence data were arranged into a matrix which was then resorted with the aim of grouping releves with similar species compositions and species with similar releve compositions. This phytosociological analysis reveals both the species that tend to consistently occur together in the vegetation studied and the releves that are floristically related. In this paper the term association is used to describe groups of species that are jointly present and jointly absent in a large number of releves in the study area and the term subassociation is used to describe groups of species that positively and negatively co-occur within the matrices defined by the associations. The matrices for the two associations recognized are presented in full as the best single device for clearly presenting the floristic

TABLE 1

PRECIPITATION DATA FOR STRATHGORDON (8 YEARS) AND HARTZ MOUNTAINS (12 YEARS)

	J	F	M	A	M	J	J	A	S	O	N	D	TOTAL
Strathgordon													
Mean (mm)	137	96	137	234	272	257	294	267	292	207	194	243	2630
Raindays	17	11	16	21	22	23	25	23	22	21	19	24	244
Hartz Mountains													
Mean (mm)	91	95	116	184	205	152	146	139	182	142	142	113	1707

relationships of the vegetation, including floristic continua that would not be revealed by a simple listing of species by types defined on the basis of structure and dominance. They also allow the reader to assess my classificatory judgments and to make realistic comparisons with data collected elsewhere. The procedure and terminology used are closely similar to those used by some practitioners of the continental school of phytosociology (Mueller-Dombois and Ellenberg 1974). However, no attempt can be made to construct truly representative formal syntaxonomies (Braun-Blanquet 1932) for Australian vegetation without widespread collecting of releve data. Thus the associations and subassociations revealed by analysis are highly unlikely to be universal for the species concerned, although they are real for the study area.

Species lists from Mt Picton and the Eastern Arthur Range formed the basis for floristic analysis. In the case of Mt Picton the list applies to the north face, the summit ridge, the northern shelves and Hewardia Ridge. It does not include species confined to *Leptospermum nitidum* closed-scrub or *Nothofagus cunninghamii* closed-forest, but does include the species found only in *Eucalyptus coccifera* open-forest. The Eastern Arthur Range list includes all the species observed in a traverse of the range from 5 (figure 2) to Federation Peak and Hanging Lake. This traverse passed through all the moors of the upper part of the range and some of the forest and scrub. The lists made from collections and field observations were supplemented by records contributed by Mr. T. Moscal and Mr. R. Williams. The presence or absence of species found in the Eastern Arthur Range or Mt Picton on other mountains of Tasmania was determined from the literature for Mt Wellington (Ratkowsky and Ratkowsky 1976), from the literature and my unpublished notes for Mt Field (Davies 1978), Mt Rufus (Davies 1978), Cradle Mountain (Sutton 1929) and the West Coast Range (Kirkpatrick 1977), and from my unpublished notes for Mt Bobs/Boomerang, Hartz Mountains and the Walls of Jerusalem.

SPECIES ASSOCIATIONS

Tables 2 and 3 while revealing some strong associations between certain groups of species, show the essentially continuous nature of floristic variation within and between the two mountains. The releves in the first table are characterized by the high constancy of *Donatia novae-zelandiae, Oreobolus pumilio, Carpha alpina, Epacris serpyllifolia, Calorphus minor, Sprengelia incarnata, Drosera arcturi* and *Pentachrondra pumila,* an association common in the West Coast Range (Kirkpatrick 1977), at Cradle Mountain (Sutton 1928) and undoubtedly elsewhere in the western mountains. The subassociations grade into each other in a sequence from low elevation Picton releves to high elevation Eastern Arthur releves. The subassociation consisting of *Oreobolus acutifolius, Bauera rubioides* and *Gleichenia alpina* is confined to the shelves on the northern and western slopes of Mt Picton. The overlapping subassociation consisting of *Gleichenia alpina, Lycopodium fastigiatum* and *Celmisia longifolia* again consists entirely of Mt Picton releves. The two large and overlapping subassociations of *Anenome crassifolia-Isophysis tasmanica-Diplaspis cordifolia* and *Diplaspis cordifolia-Actinotus moorei-Dracophyllum milliganii-Helichrysum pumilum* are found in both ranges. The sub-

TABLE 2

THE LOW CLOSED-HEATH ASSOCIATION

	RELEVES									
	1	2	3	4	5	7	8	9	10	6
Donatia novae-zelandiae	x	x	x	x	x	x	x	x	x	x
Oreobolus pumilio	x	x	x	x	x	x	x	x	x	x
Carpha alpina	x	x	x	x	x	x	x	x	x	x
Epacris serpyllifolia	x	x	x	x	x	x	x	x	x	
Calorophys lateriflorus	x	x	x	x	x	x	x	x	x	
Sprengelia incarnata	x		x	x	x	x	x	x	x	x
Drosera arcturi	x		x	x	x	x	x	x	x	x
Pentachondra pumila	x	x	x	x	x	x	x		x	
Actinotus suffocata	x	x	x	x		x	x		x	
Astelia alpina	x	x	x		x	x	x	x		
Oreobolus acutifolius	x	x	x							
Bauera rubioides	x	x	x		x			x		
Gleichenia alpina	x	x	x	x						
Lycopodium fastigiatum		x	x	x					x	
Celmisia longifolia		x	x	x				x		
Anenome crassifolia		x	x	x	x		x	x		
Eucalyptus vernicosa			x	x	x	x				
Isophysis tasmanica		x	x	x	x	x	x	x		
Diplaspis cordifolia		x		x	x	x	x	x	x	
Actinotus moorei			x	x	x	x	x	x	x	
Dracophyllum milliganii			x	x	x	x	x	x	x	
Helichrysum pumilum				x	x	x	x	x	x	
Ewartia mereditheae						x	x	x	x	
Forstera bellidifolia						x	x	x	x	
Richea curtiseae						x	x		x	
Diselma archeri						x	x		x	
Euphrasia hookeri					x	x			x	x
Erigeron stellatus		x	x		x	x		x	x	x
Mitrasacme archeri				x			x		x	x
Abrotonella forsterioides						x	x		x	x
Euphrasia spp.	x			x	x			x		
Helichrysum milliganii			x	x		x	x			x
Xyris marginata				x	x				x	
Cyathodes dealbata	x					x	x			
Stylidium graminifolium	x		x							
Drosera pygmaea	x			x						
Rubus gunnianus		x	x							
Orites revoluta			x	x						
Richea scoparia			x	x						
Danthonia sp.							x			x

Additional species: *Gaimardia fitzgeraldii, Centrolepis monogyna, Microlaena tasmanica (1); Haloragis montana, Diplarrhena latifolia, Leptospermum nitidum, Senecio pectinatus* (2); *Leucopogon milliganii, Cyathodes petiolaris, Richea milliganii* (3); *Exocarpos humifusus, Monotoca submutica, Scaevola hookeri, Persoonia gunnii, Blandfordia punicea, Drimys lanceolata* (4); *Actinotus bellidioides, Baeckea leptocaulis, Milligania densiflora* (5); *Pterygopappus lawrencii, Celmisia saxifraga* (6); *Gentianella diemensis* (7).

High Mountain Vegetation - Eastern Arthur Range and Mount Picton

TABLE 3

THE HEATH, SCRUB AND FOREST ASSOCIATION

	RELEVE													
	12	13	14	18	20	17	24	25	23	15	16	11	21	22
Structure	CS	CH	OH	OH	CH	LOF	CS	OS	CS	OH	CH	OF	CS	CH
Richea scoparia	x	x	x	x	D	x	D	x	D	x	D		x	D
Astelia alpina	x	x	x	x	x	x	x	x	x	x	x	x		x
Drimys lanceolata	x	x	x	x	x	x	x	x	x		x	x		x
Nothofagus cunninghamii	D				x	x	x	x	D	x	D	x	x	x
Exocarpos humifusus	x	x		x	x	x		x	x	x	x	x		x
Hierochloe fraseri	x	x	x	x										
Trochocarpa cunninghamii	x	x	x	x		x	x							
Richea sprengeloides	x	x	x	x	x							x		
Coprosma nitida	x	x	x	x	x						x	x		
Helichrysum backhousii	x	x	x					x	x		x			
Prionotes cerinthoides	x			x	x	x	x		x		x	x	x	
Senecio leptocarpus		x		x	x	x	x				x	x		x
Isophysis tasmanica				x	x	x	x	x	x	x				
Anemone crassifolia				x	x	x	x	x	x	x				
Richea pandanifolia	x	x		x	x	x	x	x					x	
Athrotaxis selaginoides				x	x	D		D					x	x
Uncinia compacta				x			x	x						x
Euphrasia spp.			x	x	x	x					x			
Erigeron stellatus				x	x	x				x				
Cyathodes parvifolia	x	x			x		x	x	x	x	x	x		
Eucryphia milliganii				x			x	x	x	x	x	x		
Epacris serpyllifolia				x			x	x	x	x	x	x		
Bauera rubioides								x	x	x	x	x		
Eucalyptus vernicosa								x	x	D	x	x		
Monotoca submutica									x	x	x	x		
Pentachondra pumila			x	x	x	x		x			x			x
Oreobolus acutifolius				x		x		x		x	x			x
Carpha alpina		x	x	x		x		x						x
Orites diversifolia	x	x				x		x		x		x		x
Dracophyllum milliganii				x		x		x		x			x	
Diplarrhena latifolia				x			x			x			x	x
Diplaspis cordifolia				x	x			x						x
Celmisia longifolia								x	x	x				x
Persoonia gunnii	x			x						x	x			
Orites revoluta	x	x								x	x			
Poa sp.	x			x				x						x
Olearia pinifolia	x	x			x									x
Tetracarpaea tasmanica							x	x		x		x		
Calorophus lateriflorus		x						x	x			x		
Telopea truncata	x									x		x		
Gahnia grandis		x								x		x		
Richea milliganii							x			x		x		
Cenarrhenes nitida										x	x	x		
Olearia persoonioides							x						x	
Olearia ledifolia	x			x	x									
Luzula spp.	x			x										
Gaultheria hispida	x	x												
Oxalis lactea		x		x										x
Rubus gunnianus		x	x											

	12	13	14	18	20	17	24	25	23	15	16	11	21	22
Haloragis montana		x				x								
Mitrasacme archeri			x	x		x								
Geum talbotianum			x	x										
Dichosciadeum ranunculaceum			x	x	x									
Danthonia spp.			x	x										
Aciphylla procumbens			x	x										
Celmisia saxifraga			x	x										
Oreobolus pumilio				x				x		x				
Sprengelia incarnata								x		x		x		
Actinotus moorei				x						x				
Agastachys odorata									x	x				
Cyathodes petiolaris									x	x				
Blandfordia punicea				x						x				
Richea curtiseae				x						x				
Pimelea milliganii				x						x				
Forstera bellidifolia						x		x						
Drosera arcturi				x		x		x						
Archeria comberi				x		x							x	
Abrotonella scapigera				x										x
Gentianella diemensis				x	x									
Microlaena tasmanica				x				x						
Donatia novae-zelandiae				x				x						
Orites milliganii					x								x	
Senecio primulifolius							x						x	x

D = dominant, CH = closed-heath, CS = closed-scrub, LOF = low open-forest, CF = open forest, OH = open-heath, OS = open-scrub.

Additional species: *Eucalyptus coccifera* (D), *Gleichenia alpina, Leptospermum nitidum, Lomatia polymorpha, Banksia marginata, Melaleuca squamea, Anodopetalum biglandulosum* (11); *Atherosperma moschatum* (12); *Ewartia planchonii, Podocarpus lawrencii* (D), *Polystichum proliferum* (13); *Acaena montana, Archeria serpyllifolia* (D); *Ewartia mereditheae, Leptospermum rupestre, Orites acicularis* (14); *Helichrysum pumilum* (15); *Archeria hirtella, Monotoca empetrifolia, Lycopodium scariosum* (17); *Milligania stylosa, Grammitis armstrongii, Cyathodes dealbata, Abrotonella forsterioides, Diselma archeri* (18); *Nothofagus gunnii* (D)(21); *Helichrysum milliganii* (22); *Blechnum wattsii* (24).

association *Richea curtiseae-Ewartia mereditheae-Forstera bellidifolia-Diselma archeri* is confined to the Eastern Arthurs, and the weak subassociation *Euphrasia hookeri-Erigeron stellulatus-Abrotonella forsterioides-Mitrasacme archeri* is found on some of the higher moors of the Eastern Arthurs.

The species characterizing the association shown in table 3 are *Richea scoparia, Astelia alpina, Drimys lanceolata, Nothofagus cunninghamii* and *Exocarpos humifusus*. As in the case of the first association, the subassociations overlap between releves (table 3). *Hierochloe fraseri-Trochocarpa cunninghamii-Helichrysum backhousei-Richea sprengeloides* is the subassociation found largely on highly exposed, well-drained rocky areas. Another strong subassociation, consisting of *Bauera rubioides, Eucalyptus vernicosa, Monotoca submutica, Eucryphia milliganii* and *Epacris serpyllifolia* occurs in less exposed situations on rocky well-drained sites. The other subassociations appear to relate to a variety of microhabitat conditions, most importantly soil depth, exposure and drainage.

High Mountain Vegetation - Eastern Arthur Range and Mount Picton

THE PLANT COMMUNITIES OF MT PICTON

The altitudinal sequence of plant communities on well-drained sites on the northern face of Mt Picton consists of *Nothofagus cunninghamii-Atherosperma moschatum* closed-forest on the slopes of Red Rag Scarp (3 km north of Mt Picton; alt. 400 m) *Eucalyptus coccifera* open-forest to low open-forest from roughly 800 m to 1040 m (11, table 3; plate 1), *Nothofagus cunninghamii* closed-scrub from 1040 m to 1100 m (12, table 3), *Podocarpus lawrencii* closed-heath from 1100 m to 1190 m (13, table 3; plate 1) and *Archeria serpyllifolia* open-heath (14, table 3) which is found in the most exposed situations at the higher altitudes. *Eucalyptus vernicosa* open-heath (15, table 3) is found in well-drained situations marginal to the *Donatia novae-zelandiae-Epacris serpyllifolia* low closed-heath occupying areas of poor drainage and shallow soils on mudstone shelves (1-4, table 3; plate 1). Communities dominated by herbs are largely confined to ill-drained sites with deep soils, and are restricted in area. *Gahnia grandis* open tussock-sedgeland is the most extensive of these communities, *Milligania densiflora* closed-herbland and *Astelia alpina* closed herbland being restricted to flats around lakes and long and gently sloping drainage channels (plate 1).

An interesting herbaceous community has formed along a drainage channel near 3 (figure 2, plate 1), where hummocks with the form of bolster plants are found above a predominantly subterranean stream. These hummocks support a complete cover less than one centimetre tall of *Ewartia planchonii, Rubus gunnianus, Acaena montana, Plantago tasmanica, Haloragis montana, Cotula* sp., *Drosera arcturi, D. pygmaea* and an unidentified small tufted grass. Occasional individuals of *Richea pandanifolia* and *R. scoparia* are emergent from this marsupial-grazed sward (plate 1). Communities of similar physiognomy occur on physiographically similar sites near Mt Rufus (Davies 1978), near Cradle Mountain and at the Walls of Jerusalem. The origin of the bolster-shaped hummocks in the latter areas at least seems unlikely to be through the death of bolster plants and subsequent colonization by other species as there is no evidence of such a process occurring at present. However, progressive colonization of *Sphagnum* mounds by grasses and herbs can be observed at these localities.

THE PLANT COMMUNITIES OF THE EASTERN ARTHUR RANGE

The vegetation of the Eastern Arthur Range does not exhibit the clear altitudinal zonation found on the northern face of Mt Picton. On the lower slopes of the range to an altitude of approximately 900 m the following alliances (*sensu* Specht, Roe and Broughton 1974) are widespread: *Athrotaxis selaginoides-Nothofagus cunninghamii* closed-forest, *N. cunninghamii* closed- forest, *Eucalyptus nitida* open-forest and open-scrub, *Leptospermum nitidum* closed-scrub, *Gymnoschoenus sphaerocephalus* hummock sedgeland. Above this altitude the vegetation is a complex consisting largely of heath, scrub and low forest. Forest, mostly dominated by *A. selaginoides,* occurs mainly below the cliffs and steep rocky slopes of the eastern slopes of the range. The structure varies from low open-forest with prostrate shrubs and herbs in the openings (e.g. 17, table 3) through low closed-forest to closed-forest in the most sheltered situations with deeper soils than those generally found on the higher parts of the range.

The exposed western slopes above 900 m are almost entirely covered with scrub. *Richea scoparia* closed-scrub (e.g. 24, table 3) dominates the steeper slopes and on gentler slopes merges into *A. selaginoides* open-scrub with a dense understorey of tall shrubs dominated by *R. scoparia* (plate 2). Along the margins of those parts of the closed-heath where drainage conditions ensure constant moisture in the soil the *R. scoparia* understorey is replaced by an understorey of diverse height and dominance (e.g. 25, table 3). On the upper eastern face of the range there are at least two small patches of deciduous closed-scrub dominated by *Nothofagus gunnii* (e.g. 21, table 3).

R. scoparia scrub grades into *R. scoparia* heath (e.g. 20 and 22, table 3) with

increasing exposure and shallowness of soils on moderate to steep west-facing slopes. With a combination of more favourable edaphic and topographic conditions krummholtz *Nothofagus cunninghamii* co-dominates with *R. scoparia* (e.g. 23, table 3). The areas occupied by this community appear to be such that moisture stress would occur with a lesser frequency than in most of the area occupied by *R. scoparia* heath.

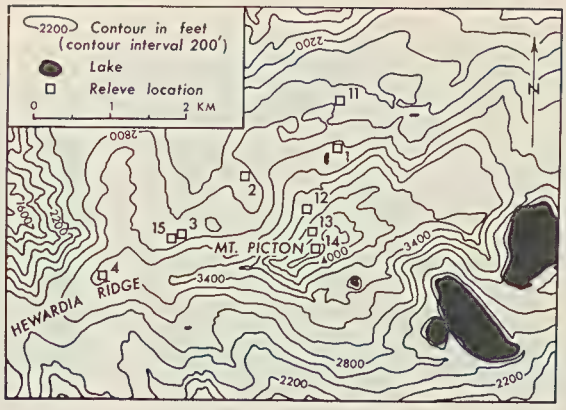


FIG.3.- The location of releves at Mt Picton

Low closed-heath dominated variously and in mixture by bolster plants (*Donatia novae-zelandiae*, *Abrotonella forsterioides*, *Dracophyllum minimum* and *Pterygopappus lawrencii*), shrubs (*Dracophyllum milliganii* and *Epacris serpyllifolia*), and tussock and mat-forming graminoids (*Oreobolus pumilio*, *Carpha alpina* and *Isophysis tasmanica*) occurs on ill-drained areas, usually of gentle slope (e.g. table 2; plate 2). The bolster plant cover increases with altitude as does the number of species of bolster plant. The low closed-heath at site 5 virtually lacks bolster species, *D. novae-zelandiae* being rare, and *I. tasmanica*, *O. pumilio* and *D. milliganii* being dominant. In contrast, all the bolster species known to be present in the range form a coalescing series of cushions at 6 in the wind gap to the west of Federation Peak. *Donatia* is the common bolster plant on all the Eastern Arthur moors, *Abrotonella* being widespread but infrequent, and *Pterygopappus* and *Dracophyllum* being confined to the highest altitudes.

The quartzite monolith of Federation Peak is covered extremely sparsely by small tussock grasses in the genera *Poa*, *Danthonia* and *Hierochloe* and small shrubs such as *Richea sprengeloides* and *Archeria serpyllifolia*. Large and soft-leaved herbs such as *Geum talbotianum*, *Aciphylla procumbens*, *Milligania stylosa* and *Dichosciadeum ranunculaceum* dominate sheltered crevices and cracks. Cliff faces that are sheltered from the sun by their aspect and subject to almost constant seepage support almost pure herblands of *Milligania densiflora*.

DISCUSSION

Although Mt Picton and the Eastern Arthur Range share at least 76 out of the pooled list of 128 species, they differ markedly in their vegetation. The clear altitudinal zonation present on Mt Picton is not only lacking in the Eastern Arthur Range but also includes two vegetation types of some area, *Eucalyptus coccifera* open-forest and *Podocarpus lawrencii* closed-heath, completely absent from the latter range. A range of communities dominated by either *Athrotaxis selaginoides* and *Richea scoparia* was not observed on Mt Picton, although small areas of communities dominated by the former species have survived in parts of the South Picton Range where fires have not reached, and the latter species is widespread. *A. selaginoides* has extreme fire susceptibility in common with *Nothofagus gunnii* and *Diselma archeri*, two other species found in the Eastern Arthur Range but not on Mt Picton. The latter two species are rare in the Eastern Arthur Range and *A. selaginoides* has much smaller trunks at equivalent altitudes than trees observed at Mt Bobs, the Boomerang, Mt Anne, Cradle Mountain and the West Coast Range. These facts suggest that in relatively recent times, perhaps only two or

High Mountain Vegetation - Eastern Arthur Range and Mount Picton

PLATE 1

Open-heath on the summit of Mt Picton looking east (top left); *Donatia* low closed-heath and *Eucalyptus coccifera* open-scrub at North Lake, Mt Picton (top right); *Podocarpus lawrencii* closed-heath with emergent *Richea pandanifolia* on the margins of the boulder stream on the north face of Mt Picton (centre left). *Donatia* low closed-heath along watercourse, *Astelia alpina* closed-herbland and *Nothofagus cunninghamii* open-scrub in an area formerly dominated by *Athrotaxis selaginoides* on the northern shelf of Mt Picton (centre right); *Isophysis-Donatia* low closed-heath with *Eucalyptus vernicosa* heath on the rises at site 3 (fig. 2) (bottom left); *Plantago-Ewartia* herbland on raised mounds along a subterranean stream near site 3 (fig. 2) (bottom right).

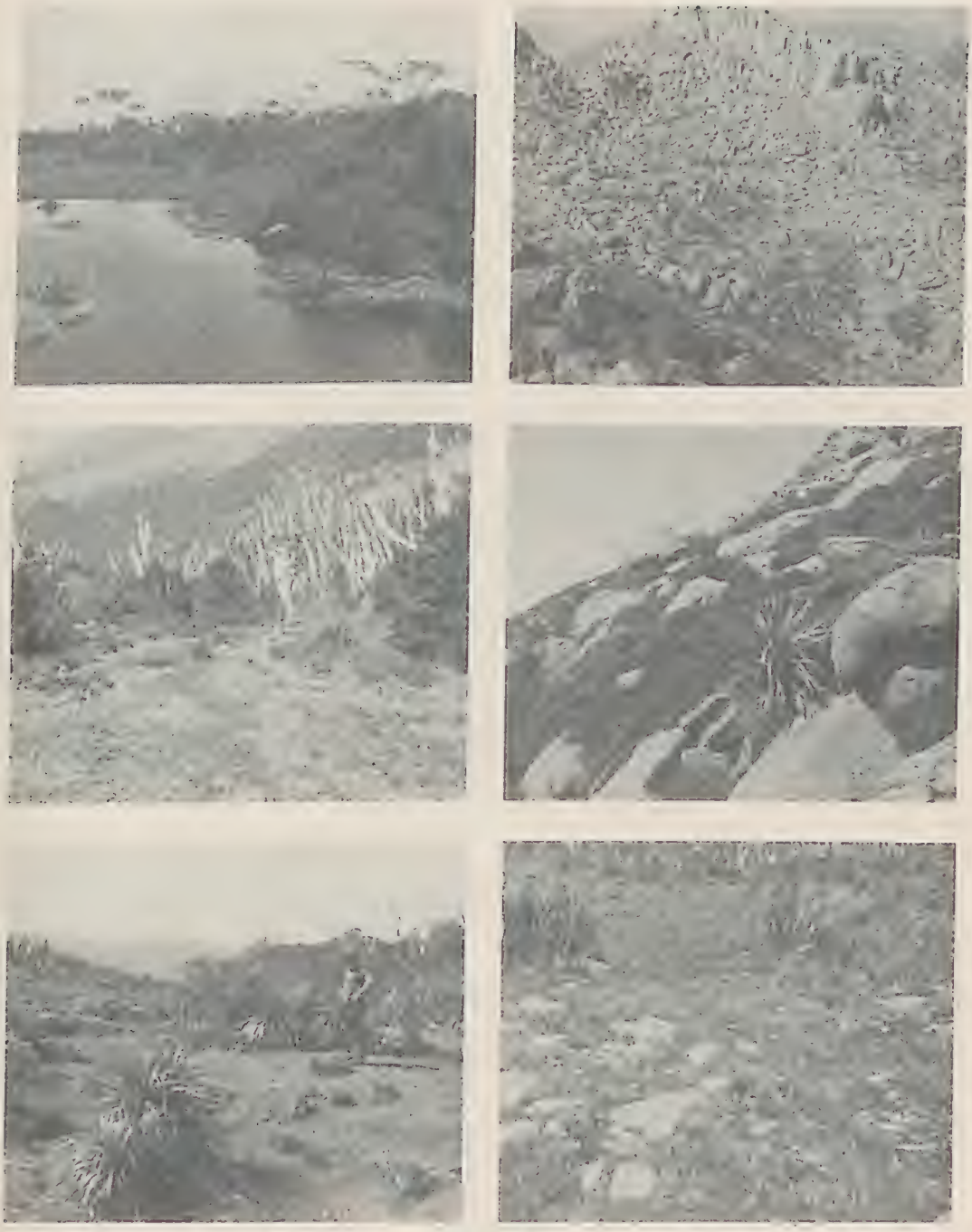


PLATE 1.

High Mountain Vegetation - Eastern Arthur Range and Mount Picton

PLATE 2

Epacris serpyllifolia-Isophysis-Dracophyllum milliganii low closed-heath at site 5. *Helichrysum pumilum* is in bloom (top left); Goon Moor (middleground) looking north and showing the topographic relationship between the closed-heath (dark) and low closed-heath (light). The path is visible in the bottom right-hand corner (top right); closed-scrub and *Nothofagus cunninghamii* low closed-forest on the steep eastern slopes of the Eastern Arthur Range (middle left); *Richea scoparia* closed-heath and closed scrub with emergent *Athrotaxis selaginoides* (the dark tree) on the western slopes of the Eastern Arthur Range (middle right); Erosion in the low closed-heath at Thwaites Plateau. Wind stripes are evident in the vegetation and these have been accentuated by foot traffic (bottom left); The southern shore of Hanging Lake looking towards its exit. Low closed-heath in the foreground, *Diselma archeri* and krummholtz *A. selaginoides* along the lake shore and *R. scoparia* closed-heath on the opposite slopes (bottom right).

PLATE 2.

three centuries ago, most of the top of the Eastern Arthur Range was burnt out and has since been slowly recolonized by *A. selaginoides* and *D. archeri*, a process that appears not to be complete. The apparent absence of *Microcachrys tetragona* from both mountains is somewhat puzzling as this species is abundant throughout most of the western mountains of Tasmania. Its lack of resistance to fire could explain its absence from Mt Picton which has been burnt in this century. Its absence from the Eastern Arthurs is less easily explained, although it has less of a tendency to occur along streams, which protect some adjacent plants during fire, than the three fire sensitive species found in the Eastern Arthur Range. Climatic control of its absence seems unlikely given the abundance of the species on the nearby Mt Bobs-Boomerang complex. Shallow, peaty soils on glacially eroded quartzose rocks support *Microcachrys* throughout much of its range, making edaphic exclusion unlikely. The apparent absence of another gymnosperm, *Podocarpus lawrencii*, from the Eastern Arthur Range may result from the relative lack of boulder streams and stable scree slopes in this range. These form the main habitat for the species elsewhere in the state (Martin 1940, Jackson 1973, Kirkpatrick 1977).

Some of the differences in the flora and vegetation between the two mountains may be accounted for by differences in fire history; however, their differing geology may be more important. Both mudstone and dolerite, the rocks which form Mt Picton, weather faster than the Eastern Arthur Range quartzite and their weathering products contain more clay and more plant nutrients. Species such as *Orites acicularis* and *O. revoluta* that occur typically on mountains with relatively deeper, more clayey and fertile soils are present on Mt Picton but are absent from the Eastern Arthur Range, and species such as *Orites milliganii* and *Pimelea milliganii* that are typical of the quartzite mountains of the west are found in the Eastern Arthur Range but not on Mt Picton.

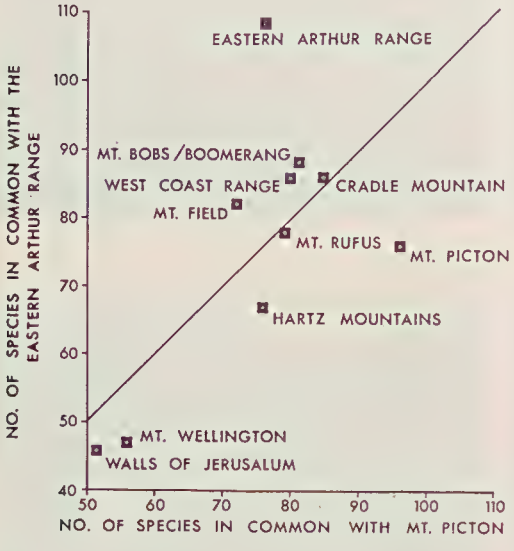


FIG.4.- Floristic similarities between Mt Picton, the Eastern Arthur Range and other mountains.

The importance of surface geology is also hinted at in figure 4 which shown that the mountains with a greater number of species in common with Mt Picton than the Eastern Arthur Range are those that could be expected to have the deeper, more clay rich and more fertile soils out of the mountains included in the analysis. The Walls of Jerusalem and Mt Rufus have considerable areas of dolerite and also include soils on siltstone. These latter soils are deep and free of the lag deposit of rocks that partially covers most dolerite soils. They are some of the few alpine soils in Tasmania on which there can be found large areas of vegetation dominated by grasses and forbs. The Hartz Mountains and Mt Wellington consist of dolerite and occur in areas of relatively low rainfall. All of the other ranges included in the analysis have some areas of dolerite within the high mountain zone. However, the West Coast Range, Cradle Mountain and Mt Bobs/Boomerang have large areas of highly siliceous substrata and the four ranges occur in areas of extremely high precipitation which would result in more leaching of nutrients than would be experienced on drier mountains of similar surface geology.

The high mountain floras of Mt Picton and the Eastern Arthur Range include high proportions of Tasmanian endemic species (Eastern Arthur Range 60 per cent, Mt Picton 57 per cent). The nearby Mt Bobs/Boomerang complex has a similarly high figure (57 per cent) compared with the (approximate) 50 per cent of Cradle Mountain and the West Coast Range and the (approximate) 33 per cent of Mt Wellington. However, only one species found on the mountains studied here is an endemic confined to the southern mountains in Tasmania (*Senecio primulifolius*), suggesting a screening of species that occur elsewhere than Tasmania by climatic and edaphic factors rather than a distinct development of local endemism.

The number of observed species in the high mountain flora of the two ranges is relatively low when compared with some other Tasmanian mountains. The Eastern Arthur Range has 108 species and Mt Picton 96, compared with 140 at the Walls of Jerusalem, 142 at Mt Rufus, 144 at Mt Field and 178 at Cradle Mountain. Other isolated and small high mountain 'islands' have similarly small floras (Hartz Mountains 104, Mt Bobs/Boomerang 114, West Coast Range (a series of 'islands') 118, Mt Wellington 121). Habitat island effects (McArthur and Wilson 1967) may be important in explaining this variation in species numbers.

Federation Peak, the highest point in the Eastern Arthur Range, provides one of the main goals for wilderness recreation in southeastern Australia, and with the rest of the range is included in the South-West National Park. A rapidly increasing number of walkers are traversing the range. This foot traffic has been sufficient to create a well-worn track through most of its length, a spreading muddy morass in some flat areas and a line of erosion on some steep slopes. The track passes through all the high moors, the low closed-heath of which is one of the more susceptible of the high mountain vegetation types to disturbance by trampling (Calais, personal communication). Mt Picton lies outside the national park and the state of the tracks on the slopes of the mountain suggest that they are older but less frequently used. The impact of trampling is localized but readily apparent. The effects of nutrient concentration around campsites are more subtle, leading to a qualitative change in the flora, as by the invasion of exotics, although this has not yet been observed.

The vegetation of both mountains is sensitive to fire. In the case of Mt Picton there is little doubt that all species found on the mountain at present would return after a fire, as the extremely fire-susceptible species are absent. However, the severe accelerated erosion that follows fire in the Tasmanian high country (Jackson 1973) leads to a long-lasting reduction in vegetation cover. In the case of the Eastern Arthur Range a fire would lead to the loss of the gymnosperm species and *Nothofagus gunnii* from the flora and a reduction in the stature and cover of the vegetation. The fire hazard has increased in both areas in recent years. Roads and forestry regeneration operations which require the use of fire have penetrated to the southern, eastern and northern lower slopes of Mt Picton, and recreational use of the Eastern Arthur Range has increased. Whether planned burning of inflammable vegetation types to the windward of fire-susceptible mountain vegetation increases or decreases the likelihood of fire in the mountains is still open to question, given that one escape of fire could change the nature of mountain vegetation for centuries.

ACKNOWLEDGEMENTS

It gives me pleasure to thank Adrian Bowden (plate 2) for help in the field, Chris Harwood and an anonymous referee for critically reading the manuscript, Terese Flannagan for her critical typing and Kate Morris for drawing the figures.

REFERENCES

Braun-Blanquet, J., 1932: PLANT SOCIOLOGY: THE STUDY OF PLANT COMMUNITIES. (Translated by G.D. Fuller and H.S. Conard). McGraw Hill, New York and London.

Cockayne, L., 1928: THE VEGETATION OF NEW ZEALAND. Engelman, Leipzig.

Costin, A.B., 1973: Characteristics and use of Australian high country. *In* Banks, M.R. (ed): THE LAKE COUNTRY OF TASMANIA. Royal Society of Tasmania, Hobart, 1-23.

Curtis, W.M., 1963: THE STUDENT'S FLORA OF TASMANIA, PART II. Government Printer, Tasmania.

_____, 1967: THE STUDENT'S FLORA OF TASMANIA, PART III. Government Printer, Tasmania.

_____ and Morris, D.I., 1975: THE STUDENT'S FLORA OF TASMANIA, PART I. (2nd Ed.), Government Printer, Tasmania.

Davies, J.B., 1978: Alpine and subalpine communities of the Mt. Field National Park and Mt. Rufus. Unpublished Honours Thesis, University of Tasmania.

Jackson, W.D., 1973: Vegetation of the Central Plateau. *In* Banks, M.R., (ed.): THE LAKE COUNTRY OF TASMANIA. Royal Society of Tasmania, Hobart, 61-85

Kirkpatrick, J.B., 1977: Native vegetation of the West Coast Region of Tasmania. *In* Banks, M.R., and Kirkpatrick, J.B. (eds): LANDSCAPE AND MAN. Royal Society of Tasmania, Hobart, 55-80.

Martin, D., 1940: The vegetation of Mt Wellington, Tasmania. *Pap. Proc. R. Soc. Tasm.*, 9: 97-124.

McArthur, R.H. and Wilson, E.O., 1967: THE THEORY OF ISLAND BIOGEOGRAPHY. Princeton Uni. Press, Princeton

Mueller-Dombois, D. and Ellenberg, H., 1974: AIMS AND METHODS OF VEGETATION ECOLOGY. Wiley International.

Ratkowsky, D.A. and Ratkowsky, A.V., 1976: Changes in the abundance of the vascular plants of the Mount Wellington Range, Tasmania, following a severe fire. *Pap. Proc. R. Soc. Tasm.*, 110: 63-90.

Specht, R.L., 1970: Vegetation. *In* Leeper, G.W. (ed.): THE AUSTRALIAN ENVIRONMENT, 4th ed., CSIRO and MUP, Melbourne, 44-67.

_____, Roe, E.M. and Broughton, V.H., 1974: Conservation of the major plant communities of Australia and Papua New Guinea. *Aust. J. Bot. Suppl.* 7: 677pp.

Sutton, C.S., 1929: A sketch of the vegetation of Cradle Mt and a census of its plants. *Pap. Proc. R. Soc. Tasm.*, (1928): 132-59.

Wakefield, N.A. 1975: FERNS OF VICTORIA AND TASMANIA. Revised ed., Field Naturalists Club of Victoria, Melbourne.

Willis, J.H., 1970: A HANDBOOK TO PLANTS IN VICTORIA, VOLUME I. 2nd ed., MUP, Melbourne.

Species observed at Mt Picton and/or the Eastern Arthur Range and their recorded occurrence on other mountains

	EA	MP	BB	WC	CM	MF	HM	MR	MW	WJ
PTERIDOPHYTA										
Aspidiaceae										
Polystichum proliferum	-	x	-	-	x	x	x	x	x	x
Blechnaceae										
Blechnum wattsii Tindale	x	x	x	-	x	x	-	x	-	-
Dennstaedtaetiaceae										
Histiopteris incisa	x	-	-	-	x	x	-	x	x	-
Gleicheniaceae										
Gleichenia abscida Rodway E	x	-	x	-	-	-	-	-	-	-
G. alpina R. Br.	-	x	x	x	x	x	x	x	x	x
Hymenophyllaceae										
*Hymenophyllum peltatum**	x	-	-	-	-	-	-	-	-	-
*H. rarum**	x	-	-	-	-	-	-	-	-	-
Lycopodiaceae										
Lycopodium fascigiatum	x	x	x	-	x	x	x	x	x	x
L. scariosum	x	-	x	x	x	x	x	x	x	x
L. varium	x	-	x	-	x	x	-	x	x	-
Grammitidaceae										
Grammitis armstrongii	x	-	x	x	-	-	-	x	x	-
Polypodiaceae										
*Microsorium diversifolium**	-	x	-	-	-	-	-	-	-	-
GYNOSPERMAE										
Cupressaceae										
Diselma archeri E	x	-	x	x	x	x	-	x	-	x
Podocarpaceae										
Phyllocladus asplenifolius E	-	x	x	x	x	x	x	x	-	-
Podocarpus lawrencii	-	x	x	x	x	x	x	x	x	x
Taxodiaceae										
Athrotaxis selaginoides E	x	-	x	x	x	x	x	-	-	-
MONOCOTYLEDONEAE										
Centrolepidaceae										
Centrolepis monogyna Benth. E	x	x	-	x	x	-	x	-	x	-
Gaimardia fitzgeraldii F. Muell. + Rodway E	x	x	-	x	-	x	-	-	-	-
Trithuria filamentosa Rodway* E	-	x	-	-	x	-	-	x	-	-
Cyperaceae										
Carpha alpina	x	x	x	x	x	x	x	x	x	x
Gahnia grandis	x	x	x	x	x	x	x	x	x	-
Oreobolus acutifolius S.T. Blake E	x	x	x	x	x	x	x	x	-	x
O. pumilio	x	x	x	x	x	x	x	x	x	x
Scirpus spp.	-	x	x	-	x	x	x	-	x	x
Uncinia compacta	x	-	x	x	x	x	x	x	x	x
Gramineae										
Danthonia fortunae-hibernae	x	x	-	x	-	x	x	-	-	-
D. pauciflora R. Br.	x	x	x	x	x	-	x	x	x	-
Hierochloe fraseri	x	x	x	x	x	-	x	-	x	x
Microlaena tasmanica Hook. E.	x	x	x	x	x	-	x	x	-	-
Poa gunnii Vickery E	x	x	x	x	x	x	x	x	x	x
Hypoxidaceae										
*Campynema lineare** Labill. E	x	-	-	-	x	x	-	x	-	-
Iridaceae										
Diplarrhena latifolia Benth. E	x	x	x	x	x	x	x	x	-	x

High Mountain Vegetation - Eastern Arthur Range and Mount Picton

	EA	MP	BB	WC	CM	MF	HM	MR	MW	WJ
Isophysis tasmanica (Hook.) T. Moore E	x	x	x	x	-	x	x	-	-	-
Libertia pulchella	x	-	-	-	x	-	-	x	-	-
Juncaceae										
Luzula spp.	x	x	x	x	x	x	x	x	x	x
Liliaceae										
Astelia alpina	x	x	x	x	x	x	x	x	x	x
Blandfordia punicea Sweet E	x	x	x	x	x	-	-	x	-	-
Milligania densiflora Hook. E	x	x	x	x	x	x	x	x	-	-
M. stylosa (F. Muell. ex Hook. f.) F. Muell. ex Benth. E	x	-	-	-	-	-	x	-	-	-
Orchidaceae										
Pterostylis dubia R. Br. E	x	-	x	-	-	-	-	-	-	-
Restionaceae										
Calorophus lateriflorus	x	x	x	x	x	x	x	x	x	x
Xyridaceae										
Xyris marginata Rendle E	x	x	x	x	-	-	-	x	-	-
DICOTYLEDONEAE										
Compositae										
Abrotonella forsterioides E	x	-	x	-	-	x	-	-	x	x
A. scapigera E	x	-	x	x	x	x	x	x	-	-
Celmisia longifolia	x	x	x	x	x	x	x	x	x	x
C. saxifraga E	x	x	x	x	x	x	-	x	x	x
Cotula spp.	-	x	-	-	x	-	-	x	x	x
Erigeron stellatus	x	x	x	x	x	x	x	x	-	x
Ewartia meredithae E	x	x	x	x	x	x	x	x	-	
E. planchonii E	x	x	x	-	x	x	x	x	x	-
Helichrysum backhousii E	x	x	x	x	x	x	x	x	x	x
H. milliganii E	x	x	x	x	x	x	-	x	-	x
H. pumilum E	x	x	x	x	x	x	-	x	-	-
H. scorpioides	x	-	-	-	x	x	-	-	x	x
Olearia ledifolia E	x	x	x	x	x	x	x	x	x	x
O. persoonioides sensu lato E	x	-	x	x	x	x	x	x	x	-
O. pinifolia E	x	x	x	x	x	x	x	x	x	x
Pterygopappus lawrencii E	x	-	x	x	x	x	-	x	-	x
Senecio leptocarpus	x	x	x	x	x	x	x	-	x	x
S. primulifolius E	x	-	-	-	-	-	-	-	-	-
S. pectinatus	x	x	x	x	x	x	x	x	x	x
Cunoniaceae										
Bauera rubioides	x	x	x	x	x	x	x	x	x	x
Droseraceae										
Drosera arcturi	x	x	x	x	x	x	x	x	x	x
D. pygmaea	-	x	-	x	x	-	-	x	x	x
Epacridaceae										
Archeria comberi E	x	-	-	x	-	x	-	-	-	-
A. hirtella E	x	-	x	x	x	-	-	-	-	-
A. serpyllifolia E	x	x	x	x	x	x	x	-	-	-
Cyathodes dealbata E	x	x	x	x	x	x	x	x	x	x
C. parvifolia E	x	x	x	x	x	x	x	x	x	x
C. petiolaris E	x	x	-	x	x	x	x	x	x	x
Dracophyllum milliganii E	x	x	x	x	-	x	-	-	-	-
*D. minimum** E	x	-	x	x	x	x	x	x	-	-
Epacris serpyllifolia	x	x	x	x	x	x	x	x	x	x
Leucopogon milliganii E	-	x	-	x	x	-	-	-	-	-
Monotoca submutica Jarman E	x	x	x	x	x	-	x	x	-	-
Pentachondra pumila	x	x	x	x	x	x	x	x	x	x

	EA	MP	BB	WC	CM	MF	HM	MR	MW	WJ
Prionotes cerinthoides E	x	x	x	x	x	x	x	x	-	-
Richea curtiseae A.M. Gray E	x	-	x	-	x	-	-	-	-	-
R. milliganii E	x	x	x	x	-	x	x	-	-	-
R. pandanifolia E	x	x	x	x	x	x	x	x	-	-
R. scoparia E	x	x	x	x	x	x	x	x	x	x
R. sprengelioides E	x	x	x	x	x	x	x	x	x	x
Sprengelia incarnata	x	x	x	x	x	x	x	x	x	-
Trochocarpa cunninghamii E	x	x	x	x	x	x	x	x	-	-
Ericaceae										
Gaultheria hispida E	-	x	x	x	x	x	x	x	x	-
Escalloniaceae										
Tetracarpaea tasmanica E	x	x	x	x	x	x	x	x	x	-
Eucryphiaceae										
Eucryphia milliganii E	x	x	x	x	-	-	x	-	-	-
Fagaceae										
Nothofagus cunninghamii	x	x	x	x	x	x	x	x	x	x
N. gunnii E	x	-	x	x	x	x	-	x	-	x
Gentianaceae										
Gentianella diemensis	x	x	x	x	x	x	x	x	x	x
Goodeniaceae										
Scaevola hookeri	-	x	-	x	x	x	x	x	x	x
Haloragaceae										
Haloragis montana	x	x	x	-	x	x	x	-	x	x
Loganiaceae										
Mitrasacme archeri E	x	x	x	x	x	x	x	x	-	x
Myrtaceae										
Baeckea leptocaulis E	x	-	-	x	-	-	-	-	-	-
Eucalyptus coccifera E	-	x	-	-	x	x	x	x	x	x
E. vernicosa E	x	x	x	x	x	x	x	-	-	-
Leptospermum nitidum	x	x	x	x	x	x	x	x	-	-
L. rupestre E	-	x	-	-	x	x	x	x	x	x
Oxalidaceae										
Oxalis lactea	x	x	x	x	x	x	x	x	x	x
Plantaginaceae										
Plantago tasmanica	-	x	x	-	x	x	x	x	x	x
Proteaceae										
Agastachys odorata E	x	x	x	x	-	-	x	x	-	-
Cenarrhenes nitida E	x	x	x	x	x	x	x	x	-	-
Orites acicularis E	-	x	x	-	x	x	x	x	x	x
O. diversifolia E	x	x	x	-	-	x	x	x	x	-
O. milliganii E	x	-	-	x	-	-	-	-	-	-
O. revoluta E	-	x	x	x	x	x	x	x	x	x
Persoonia gunnii E	x	x	x	x	x	x	x	x	-	-
Telopea truncata E	-	x	x	x	x	x	x	x	-	-
Ranunculaceae										
Anemone crassifolia E	x	x	-	x	x	-	-	-	-	-
Rosaceae										
Acaena montana E	x	x	x	x	x	x	x	x	x	x
Geum talbotianum E	x	x	x	-	-	-	x	x	-	-
Rubus gunnianus E	-	x	x	x	x	x	x	x	x	x
Rubiaceae										
Coprosma nitida	x	x	x	x	x	x	x	x	x	x
Santalaceae										
Exocarpos humifusus E	x	x	x	x	x	x	x	x	x	x
Scrophulariaceae										
Euphrasia spp.	x	x	x	x	x	x	x	x	x	x

High Mountain Vegetation - Eastern Arthur Range and Mount Picton

	EA	MP	BB	WC	CK	MF	HM	MR	MW	WJ
E. hookeri E	x	-	x	x	x	-	-	-	-	-
Stylidiaceae										
Donatia novae-zelandiae	x	x	x	x	x	x	x	x	-	-
Forstera bellidifolia E	x	-	-	x	x	x	-	x	-	-
Stylidium graminifolium	-	x	x	x	x	-	x	x	-	-
Thymelaeaceae										
Pimelea milliganii E	x	-	-	x	-	-	-	-	-	-
Umbelliferae										
Aciphylla procumbens E	x	x	-	-	x	x	x	-	-	-
Actinotus bellidioides	x	-	-	-	x	x	-	x	-	-
A. moorei E	x	x	x	x	x	x	-	x	-	-
A. suffocata	x	x	x	x	x	x	-	x	-	-
Dichosciadium ranunculaceum E (var.)	x	x	x	x	x	x	-	x	-	-
Diplaspis cordifolia E	x	x	x	x	x	x	-	x	-	-
Oreomyrrhis ciliata E	x	-	x	-	x	-	-	x	-	x
Winteraceae										
Drimys lanceolata	x	x	x	x	x	x	x	x	x	x

E = Tasmanian endemic species; EA = Eastern Arthur Range; MP = Mt Picton; BB = Mt Bobs and the Boomerang; WC = West Coast Range; CM = Cradle Mountain; MF = Mt Field; HM = Hartz Mountains; MR = Mt Rufus; MW = Mt Wellington; WJ = Walls of Jerusalem; * = observed by T. Moscal or R. Williams but not by the author.

Papers and Proceedings of the Royal Society of Tasmania, Volume 114, 1980.

(ms. received 21.12.1978)

THE VEGETATION OF THE MT CAMERON WEST ABORIGINAL SITE

by M.J. Brown
National Parks and Wildlife Service, Tasmania

(with one table, two text figures and four plates)

ABSTRACT

BROWN, M.J., 1980 (31 v): The vegetation of the Mt Cameron West Aboriginal Site. *Pap. Proc. R. Soc. Tasm.*, 114: 21-34 (inc. 4 plates). ISSN 008-4703. National Parks and Wildlife Service, Hobart, Tasmania, Australia.

The vegetation of the Mt Cameron West Aboriginal Site is described. The vegetation is mapped into nine mapping units. The ecology of the plant communities which occur in each mapping unit is discussed. Much of the vegetation is ecologically brittle and reflects the combined effects of past grazing and fire regimes.

INTRODUCTION

The Mt Cameron West Aboriginal Site (144° 36'E, 40° 52'S) comprises 524 ha of land formerly included in the Woolnorth Estate on the northwestern tip of Tasmania. The site contains aboriginal rock engravings and a stone quarry of considerable archaeological significance, as well as an extensive area of middens. Hubble (1951) briefly described the coastal vegetation in the far northwest of Tasmania, and Jackson (pers. comm.) gives a detailed description of the vegetation of the Swan Bay Plain to the north of the Reserve. The following is the first account of the vegetation which occurs in the vicinity of Mt Cameron West.

THE PHYSICAL ENVIRONMENT

Climate

The climate of the area is temperate maritime and is determined largely by the transit of high and low pressure cells from the Indian and Southern Oceans (Bureau of Meteorology 1973). Prevailing winds blow mainly from two directions through Bass Strait; 270° ± 45° and 56° ± 56°. Temperature and rainfall data are not available for the study area, but conditions are probably approximated by Marrawah, Stanley and Cape Grim (table 1). The rainfall has a weak symmetrical winter maximum distribution. Summers are mild and cloudy; winters are cool and wet.

Geology and Geomorphology

Mt Cameron West dominates a low coastal plain of Quaternary alluvium and calcareous sand dunes. The mountain is composed of Tertiary alkali basalt and rises to 168 m at the southern end of the reserve. Outcrops of Precambrian metamorphic rock form rocky headlands at the northern end of the beach at Two Mile Sand. The aboriginal carvings are at the northern end of the beach in local outcrops of soft calcareous sandstone (Williams and Turner 1973, Sutherland 1972).

The coastal plain is a system of dune ridges parallel to the shore. This system is transgressed by several large parabolic or blowout dunes originating from wind erosion of previously stabilised dunes. Areas of iron concretion hardpan (coffee rock) are exposed by the removal of the overlying sand.

A number of dune barred lagoons occur in the area, and creeks flowing from two of these dissect the dune ridges and run to the sea. The larger lagoons carry extensive beds of macrophytic vegetation, and appear to provide permanent (brackish) water.

TABLE 1

Climatic data for selected stations near the Study Area

A = precipitation (mm); B = No. of raindays; C = mean daily maximum teperature (°C); D = mean daily minimum temperature (°C).

	Jan	Feb	Mar	Apr	May	June	Jul	Aug	Sept	Oct	Nov	Dec	Year
					Marrawah (144° 43' E, 40° 55' S)								
A	43	47	49	106	127	137	128	143	120	99	62	69	1130
B	12	10	15	19	23	22	26	25	25	22	16	17	232
C	19.8	22.1	19.2	17.4	14.6	12.3	12.2	12.2	13.7	14.5	15.8	17.8	16.0
D	11.7	13.8	11.6	10.6	8.7	6.9	6.5	6.5	7.8	8.1	8.3	10.6	9.3
					Stanley (145° 17' E, 40° 46' S)								
A	42	46	49	75	93	107	115	104	84	87	66	61	929
B	11	10	13	16	20	20	22	22	19	18	16	14	201
C	20.9	21.1	19.8	17.5	14.8	13.3	12.5	12.8	14.2	15.8	17.6	19.2	16.6
D	12.5	12.9	11.8	10.1	8.1	7.1	6.1	6.2	7.0	8.1	9.5	10.9	9.2
					Cape Grim (144° 44' E, 40° 44' S)								
A	43	46	52	75	92	112	122	110	85	85	62	57	941
B	10	9	11	15	18	20	21	22	19	17	14	12	188

Soils

The soils are coarse textured, marine and aeolian sand (Nicolls and Dimmock 1965). Ground water podzols occur on the poorly drained wet sites behind the dune ridge system. The soils here are strongly leached and acid, with an A horizon of siliceous sand and organic matter. Podzols and moderately leached calcareous sands are found on the better drained sites on the lower slopes of Mt Cameron West and on the tops and sides of the stabilised dunes (Hubble 1951). Loams are developed on Mt Cameron West. These loams are derived from basalt with the addition of aeolian sands. Areas of rocky scree occur on the steep southern slopes of Mt Cameron West.

THE VEGETATION

The plant communities and a checklist of species occurring in the reserve are given in the appendix. Naming of the communities follows the structural system outlined by Specht (1970), except for sedgeland-heath, a composite community in which heath and sedge species are co-dominant.

Nine major vegetation mapping units are recognisable within the reserve area (fig 1): - 1. vegetation of the littoral beach and mobile sand, 2. vegetation of the littoral rocky headland and boulder beach, 3. vegetation of the partially stabilised dunes, 4. vegetation of the stabilised dunes and slopes, 5. vegetation of the scree slopes, 6. shrubland, 7. woodland, 8. aquatic, 9. acid sedgeland-heath.

1. Littoral beach and mobile sand

Erosion of the dunes has extended the area of the beach, by the mobilisation of sand for 2-3 km inland (plate 1). Except for the occasional pioneering plants of *Cakile edentula* near the foredunes, the beach and inland blow areas are devoid of vegetation.

Isolated pockets of vegetation, and the remains of the dead shrubs occurring within the transgressive dunes indicate that the dunes and swales previously supported dense thickets of *Acacia sophorae* and *Melaleuca ericifolia* respectively. In his account of

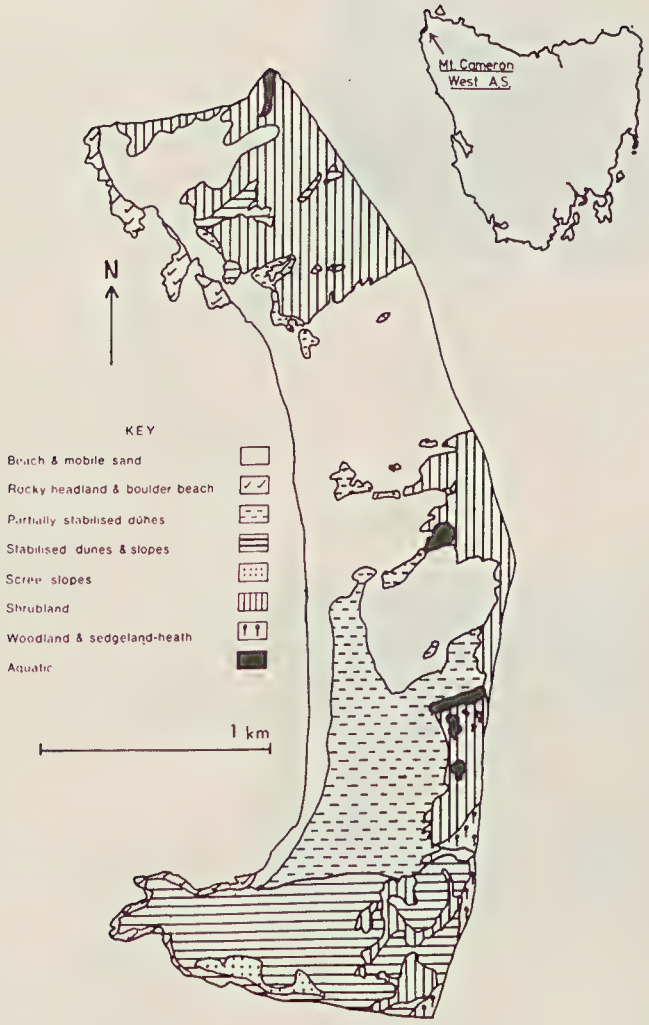


FIG.1.- Mt Cameron West Aboriginal Site: Vegetation.

PLATE 1.- The coastal plain north of Mt Cameron West. Dense scrub of *Leptospermum laevigatum* (light) and *Melaleuca ericifolia* (dark) surround the lagoons in the middle ground, and border on seral sedgelands of the beach ridges. Two large dune blowouts are visible in the background.

the aboriginal rock carvings at Mt Cameron West, Meston (1934) noted..." cattle breaking down the dunes and allowing the wind free play have destroyed the face of the country". Patches of dead *Ammophila* on the fringe of the mobile sands indicate past attempts at stabilisation.

2. Littoral rocky headland and boulder beach

Halophytic succulents from the families Ficoideae and Chenopodiaceae form the littoral vegetation on the rocky shores; open herbfields dominated by *Salicornia quinqueflora* and *Disphyma australe* occur in the lower salt spray zone, which may be subject to inundation. At higher levels of the salt spray zone the same species occupy the ground layer in open grasslands of *Stipa teretifolia*.

3. Partially stabilised dunes

The stabilised dune ridge system on the coastal plain appears to have been heavily grazed and frequently burnt, presumably to maintain a green pick for cattle, and to prevent shrubland encroachment. Sites of incipient deflation and terracettes on the sides of the steeper dunes have resulted from grazing and mechanical damage by cattle.

3.1 Foredunes.- The coastal side of the vegetated foredunes supports grasslands of *Ammophila arenaria* (marram) and *Festuca littoralis*. Isolated tufts of *Spinifex hirsutus* occur, but no extensive growth of this grass was observed. At the base of the foredunes, creeping succulents such as *Carpobrotus rossii* and herbs like *Acaena novae-zelandiae* intermingle with the grasses. The open grasslands of *Ammophila* extend well back from the frontal dunes in areas which have been previously destabilised. The lee sides of stable dunes carry a tussock grassland of *Poa poiformis* interspersed with *Scirpus nodosus*.

Carex gaudichaudiana sedgelands occupy localised sites of fresh water seepage at the base of the dune front where salinity is reduced. This species is replaced by *Carex appressa* on a few low-lying sites flanking creek outflows and by *Baumea tetragona* or *Restio tetraphyllus* in more acid situations.

3.2 Rear dunes.- The older dune ridge system behind the foredunes supports a mosaic of *Poa* grassland, *Pteridium* (bracken) fernland and sedgelands dominated by *Lomandra longifolia, Lepidosperma gladiatum* and *Scirpus nodosus* (plate 1). Fire, grazing, microtopography, drainage and the degree of calcareous deposition all affect the distribution of these communities. The presence of shrub skeletons and the vegetation on stabilised dunes at the northern end of the reserve suggest that in the absence of fire and grazing, the grassland-sedgeland associations would be replaced by shrublands of *Acacia sophorae, Myoporum insulare* and *Correa backhousiana* near the coast and *Melaleuca ericifolia* or *Leptospermum laevigatum*, respectively in poorly and well-drained situations behind. Brown, Shepherd & Jackson (unpub), suggest that in coastal areas subject to grazing, the seral *Pteridium* fernlands maintained by frequent firing are eventually replaced by grassland and sedgeland dominated by *Poa* and *Lomandra*. A succession

toward coastal heath species is likely to follow the removal of grazing and a reduced frequency of fires.

3.3 Destabilised shrublands.- Patches of shrubland are scattered through the sand-drift area.

The patches arise in two ways. Some are the result of mounds of sand sufficiently bound by dead fibrous root and rhizome material to be recolonised by abrasion resistant succulents and shrubs; other patches appear to be relict shrublands remaining after erosion of surrounding areas.

The beach sands overlying the sandstone near the aboriginal rock carvings support a low open heath of the composites, *Olearia lepidophylla* and *Calocephalus brownii* over mats of *Carpobrotus*, and *Tetragonia implexicoma*. The mats effectively bind the sand, but their distribution is patchy and sites of potential erosion are evident.

4. Stabilised dunes and slopes

4.1 Dune herbfields.- Grasslands and herbfields occur on the stabilised dunes toward the northern end of the reserve. Grasslands of *Aira caryophyllea - Vulpia bromoides* and herbfields of *Solenogyne bellioides - Plantago bellidioides* occupy the freely draining sands of the tops and lee sides of dunes. These grasslands are heavily grazed by native herbivores. Low lying flat areas are covered by closed grasslands of *Distichlis distichopylla* and closed-herbfields of *Nablonium calyceroides*. The swale hollows of impeded drainage carry the above associations at the edges of ephemeral lagoons.

4.2 Mt Cameron West and foothills.- The soils on the slopes of Mt Cameron and its associated foothills are more fertile than those of the coast plain. The vegetation is better developed and wind erosion is not a problem. However slumps and terracettes occur on the steeper slopes (plate 2). The predominant vegetation is *Poa* grassland, *Pteridium* fernland and *Lomandra* tussock-sedgeland. Isolated trees of *Eucalyptus ovata* and *Banksia marginata* dot the landscape suggesting that the original cover of the protected slopes would have been a *Eucalyptus ovata (E. obliqua?)* woodland, with a heath or scrub understorey, whilst the lower slopes, and regions of poor drainage would have been occupied by *Melaleuca ericifolia* closed-scrub. The high incidence of fire, the introduction of pasture species, and the preference of cattle for any regenerating shrub and herb species have resulted in the promotion of *Lomandra* tussocks and bracken together with a high proportion of adventive species, at the expense of the native shrubs. No regenerating eucalypts or *Banksia* were observed in the area. A secondary effect of grazing has been the establishment of extensive closed thickets of *Ulex europaeus* (gorse).

PLATE 2.- Southern slopes of Mt Cameron West. Seral grassland of *Poa* and *Lomandra* in the foreground. The scree is colonized by mats of *Tetragonia*. Terracettes have formed below the relict patch of *Melaleuca ericifolia* scrub in the middle ground.

5. Scree slopes

The steep southern slopes of Mt Cameron West support a mosaic of rocky scree, *Poa* tussock, *Pteridium*, and small thickets of *Melaleuca ericifolia* and *Leptospermum laevigatum*. Parts of the scree slopes are covered by dense hanging mats of *Tetragonia implexicoma*, although most of the lower parts of the scree have been invaded by introduced and seral species such as nettles, thistles and bracken (plate 2).

6. Shrubland

Closed-scrub is found on the stabilised frontal dunes. *Acacia sophorae, Myoporum insulare, Correa alba, C. backhousiana and Leucopogon parviflorus* predominate (plate 4). These species are replaced inland by *Melaleuca ericifolia* which forms dense shrub thickets of low floristic diversity (plate 1). The *Melaleuca* scrub occurs on the slopes of Mt Cameron West, on the exposed and lee slopes of dunes, and on the low-lying,poorly-drained flats surrounding the lagoons. On areas of better drainage, between the foothills of Mt Cameron West and the lagoons, *Melaleuca* is replaced by a closed-scrub of *Leptospermum laevigatum*. This species appears to be actively colonising fire-sere areas of bracken.

Stunted and low-lying *E. viminalis* are scattered through both these shrublands. The presence of dead stags and stumps within the thickets suggests that a more extensive low-open forest of this species may once have occurred in the area.

7. Woodland

Eucalyptus woodlands are poorly represented in the reserve but are present along the eastern boundary. The region near the south-eastern corner carries an open-woodland of *E. viminalis - E. ovata* over a *Poa* grassland and *Lomandra* tussock understorey. *E. obliqua* occurs in the same woodland, but is absent from the reserve area. A small patch of *E. viminalis* woodland over a mixture of bracken, heath and sedges occurs on the lower slopes of the eastern foothills of Mt Cameron West. These slopes grade onto flats carrying a mosaic of sedgeland-heath, and low open (mallee) woodland of *E. nitida*.

8. Aquatic

8.1 Ephemeral lagoons.- The shallow depressions of the dune swales are intermittently flooded, and carry a zoned series of plant associations which reflect the depth and duration of inundation. This zonation ranges from open-herbfields of *Myriophyllum amphibium* in the areas of longest inundation, through herbfields of *Samolus repens - Eryngium vesiculosum* to *Selliera radicans, Nablonium calyceriodes* closed-herbfields or *Distichlis distichophylla* closed-grassland.

8.2 Permanent lagoons.- The larger lagoons all contain permanent water. The two lagoons on the northern boundary, and the large lagoon in the centre of the reserve shelve fairly rapidly, and there is very little development of emergent macrophytes. The vegetation is limited to submerged aquatics such as *Myriophyllum elatinoides*.

These lagoons contrast with those to the south, which contain shallower water and carry extensive reed swamps (plate 3). The chief species present are *Triglochin procera* and *Typha*. *Myriophyllum elatinoides, Myriophyllum amphibium* and a number of unidentified submerged aquatics are also present. The emergent vegetation extends more or less across the entire surface of the lagoons. A dense floating cover of duckweed *(Lemna minor)* and water fern (*Azolla filiculoides*) was present on the larger lagoon at the time of the visit. The density of dead stems on the lagoon indicates that much of the lagoon was once covered in a *Melaleuca ericifolia* closed-scrub (plate 3). The steeper inland sides of the southern lagoons are fringed by a sedgeland of *Restio tetraphyllus* above *Scirpus inundatus*. On the shallower eastern and northern banks of the large lagoon, there is a mosaic of rushes (*Juncus caespiticius*), grasses (*Distichlis*,

PLATE 3.- Shallow lagoon covered with *Triglochin procera* and dead stems of *Melaleuca ericifolia*; Mt Cameron West is in background.

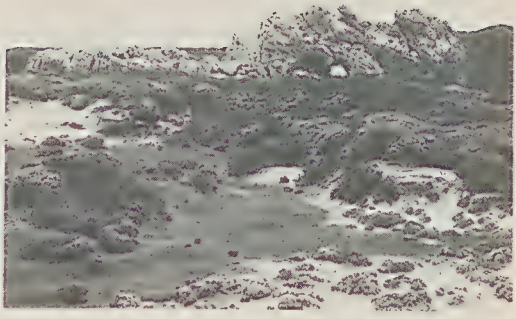


PLATE 4.- Closed heath of *Acacia sophorae* and *Correa spp.* surrounding an outcrop of Precambrian quartzite at the northern end of the reserve. An old duneblow is visible in foreground.

Poa), herbs (*Crassula helmsii, Epilobium sp.*) introduced herbs (*Plantago coronopus, Rumex*) and tussocks of the rush *Juncus maritimus* (plate 3).

This region is heavily trodden and browsed by cattle.

8.3 Riparian.- The banks of the streams and margins of outflows from fresh water soaks in the area provide specialised habitats for the development of sedgelands and semi-aquatic herbfields. The sedgelands are dominated by *Carex appressa* or *Baumea tetragona* on the banks of streams with *Scirpus inundatus* at levels of frequent inundation. The more acidophilous *Restio tetraphyllus* replaces these sedges in backwaters and other regions of standing water. At the shallower margins of streams, herbfields of *Callitriche stagnalis* and the Tasmanian endemic species *Lilaeopsis brownii* occur within sedges and rushes such as *Scirpus inundatus* and *Juncus planifolius*.

9. Acid sedgeland - heath

The eastern boundary of the reserve is flanked by acid sedgeland-heaths developed on the ground water podzols beyond the foothills of Mt Cameron West. These communities lie outside the boundary of the reserve, and only a brief description is given. The area consists of a low-open (mallee) woodland of *E. nitida* over closed-heaths of *Melaleuca squamea, M. squarrosa, Leptospermum scoparium* and *L. glaucescens*. The heath is replaced locally by sedgelands of *Restio complanatus - Lepidosperma filiforme*, or, on sites of badly impeded drainage, by *Leptocarpus tenax* sedgeland.

DISCUSSION

The native vegetation of the reserve is generally similar to other coastal types known to occur along the north-west and west coasts of Tasmania (Macphail *et al.* 1975, Jackson pers. comm.). The distribution of plants appears to be correlated with salinity, drainage, pH and microtopography. However, the vegetation has been extensively modified by burning, grazing and subsequent erosion, and by the past sowing of pasture species.

Vegetation of Mt Cameron West

A provisional scheme which outlines the inter-relationships among the major plant communities of the dunes and their hinterland is presented in fig. 2. The bare sands of the frontal dunes are colonized by species such as *Cakile*, *Spinifex* and *Festuca littoralis*. This partial stabilization allows *Poa* dominated grasslands to establish, together with rhizomatous herbs and succulents. With the subsequent stabilization and increasing humification of the sands, open-heathlands replace the grasslands on sites which are wind-exposed, whilst on sheltered sites of free drainage, *Acacia sophorae* scrub becomes dominant.

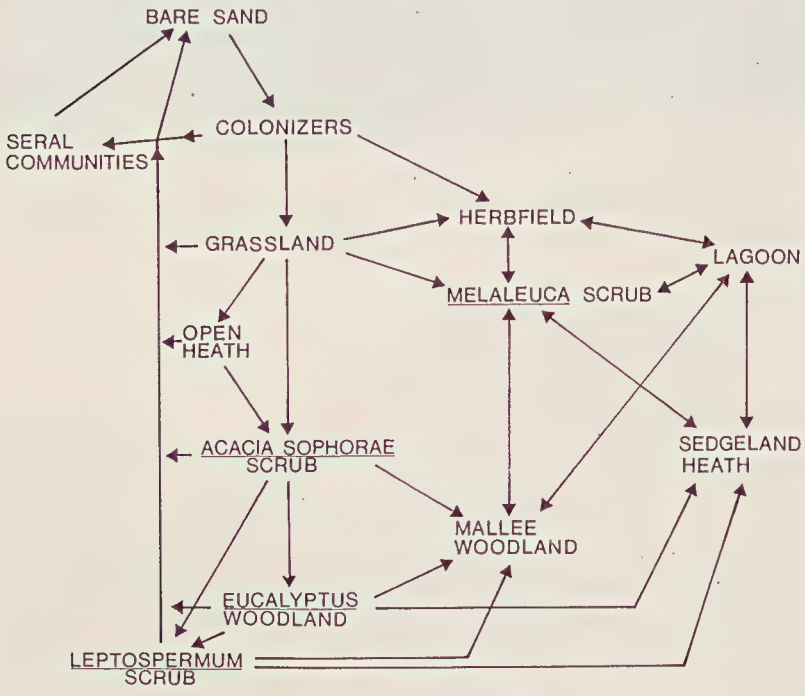


FIG. 2.- Inter-relationships among the plant communities of the dunes at Mt. Cameron West.

E. viminalis woodlands develop in areas where there is protection from salt-laden onshore winds. The understorey of the woodland is variable and *Leptospermum laevigatum* scrub, heaths, bracken, saggs and grasses all become locally prominent. The order of dominance is probably dependent on the fire regime. Fires of relatively low frequency but high intensity favour the development of *Leptospermum laevigatum* scrub (Hazard and Parsons 1977). Medium intensity - medium frequency fires favour heath species, and the grasses and saggs predominate where fires are very frequent and of low intensity. The density of bracken in the understorey varies from a few scattered plants to nearly 100% cover. This variability reflects the opportunist nature of bracken. Bracken can sprout and spread quickly after fire, but soon dies back, creating fuel for the next fire. If the next fire is not intense (i.e. occurs soon after) then grasses etc. can compete, whilst in the absence of fire, heath species will dominate and eventually replace the bracken. In the continued absence of fire, *Leptospermum laevigatum* eventually shades out the other species, and in the long term produces a monotypic stand which is perpetuated by infrequent firing.

Dune swales and areas of impeded drainage support low sedgelands and herbfields on ephemeral wetlands. *Melaleuca ericifolia* swamp scrub and woodlands occur where the

water table is reliable and sufficiently high, such as in lagoons formed where outflows of water are trapped by the dunes.

Inland, the low-lying sands have relatively low pH values, a high organic content and are strongly leached. These ground water podzols support sedgeland-heaths in areas of badly impeded drainage and low-woodlands of mallee-form *E. nitida* on better drained sites.

Destabilization of the dunes occurs when the vegetation is disturbed. Wind funnelling of the underlying sand causes undercutting of the adjacent vegetation until ultimately the whole dune may be exposed and mobilized. To some extent this process occurs naturally, e.g. when triggered by a violent storm. The erosion process may be initiated more readily after burning of the overlying vegetation. It seems probable that aboriginal occupancy of this portion of Tasmania dates from the formation of the coast (Bowdler 1974, Hope 1978). Thus fire has probably always been a feature of the environment of these dunes. However, the degree to which aboriginal fires contributed to dune destabilization is debatable. Dimmock (1957) provisionally ascribed the generally low incidence of of dune blows on Flinders Island to the absence of aboriginals. On the other hand, some early reports of Sandy Cape (to the south of the study area) describe rolling green hills suitable for sheep grazing (Macphail *et al.* 1975). Sandy Cape now consists largely of shifting sands, and the abundance of midden material in the vicinity attests to the frequency of aboriginal use of the area. Similarly, in New Zealand, Wendelken (1974) mentioned coastal areas inhabited by Maoris where burning has been part of the environment for 1000 years, but where excessive movement of sand has only recently become a problem. However, there can be little doubt that stabilized dunes which support a sparse, fire-induced, seral community are inherently more susceptible to destabilization than dunes which are more densely clad.

The advent of European man into the area has contributed to the degradation of the native vegetation in many ways. The most immediately apparent effect has been the clearing of most of the native vegetation and sowing to pasture of the fertile slopes of Mt Cameron West and its foothills.

The agistment of stock has greatly accelerated the erosion of the dunes, through mechanical damage, through over-grazing and through the too-frequent use of fire to provide a 'green pick'. Also, stock simultaneously distribute the seeds of weed species, and maintain conditions suitable for their growth.

The combination of fire and grazing can lead to 'ecological drift' (Jackson 1968), a process in which the chance elimination or promotion of particular species results in a succession of the vegetation towards a disclimax state. The disclimax is maintained by feedback mechanisms. In the present case, the predilection of stock for young regenerating herbs, grasses and shrubs places these species at a selective disadvantage when compared with the less palatable bracken, sedges and saggs. The process is then reinforced by the high fire frequency which favours vegetatively propagating species and annuals at the expense of species which propagate more slowly by seed. Thus, once it is established, the seral community tends to self-maintenance because of the need of graziers to burn off more frequently.

Left to themselves, the transgressive dunes eventually become isolated from their source of sand and stabilize (Kirkpatrick pers.comm.) However, this process may be unacceptable to land managers if the dune first engulfs land suited to grazing. It is probably for this reason that reclamation works have been carried out in the past using marram grass, a species which colonizes and binds free sand very much more rapidly than native grasses.

MANAGEMENT PROBLEMS

The vegetation of the reserve has been considerably disturbed in the past. Recovery should be hastened by the removal of cattle and a reduction in the frequency of fires.

The planting of marram grass is probably the only feasible means of rapid re-establishment of a vegetative cover on the sand drift areas, provided that this is an appropriate technique for management within a State Reserve. Subsequent colonisation by other species already present in the area (*Carpobrotus, Acaena, Cerastium, Laxmannia*) would be reasonably rapid. The blow out areas of exposed coffee rock are currently devoid of vegetation. Natural revegetation of these will be very slow, requiring the aeolian deposition of sand and subsequent colonisation by plants. Areas susceptible to destabilisation should recover once the reserve is fenced, and the cattle removed. The large tracts of gorse on the slopes of Mt Cameron West will require more intensive control methods.

The reserve contains a number of plant species, plant associations and habitats not represented or poorly represented in the present State Reserve system. These include the *Leptospermum laevigatum* scrub and *Plantago bellidioides, Solenogyne bellioides, Nablonium calyceroides* and other lagoon fringe herbfields.

ACKNOWLEDGEMENT

I wish to thank C. Harwood for making available his notes on the vegetation in the wetlands. Thanks are also due to C. Harwood and W.D. Jackson for helpful discussion of the manuscript.

REFERENCES

BOWLDER, S., 1974: Pleistocene date for Man in Tasmania. *Nature*, 252: 269.

BUREAU OF METEOROLOGY, 1973: CLIMATIC SURVEY NORTHWEST REGION 1 TASMANIA. Aust. Govt. Pub. Serv., Canberra.

CURTIS, W.M., 1963, 1967: THE STUDENTS' FLORA OF TASMANIA, Parts 2 and 3. Govt. Printer, Tasmania.

_____ and MORRIS, D.I., 1975: THE STUDENTS' FLORA OF TASMANIA. Part 1, 2nd ed., Govt. Printer, Tasmania.

DIMMOCK, G.M., 1957: The soils of Flinders Island, Tasmania. *Soils and Land Use Series No. 23*, 66pp. Divn. of Soils CSIRO.

HAZARD, J. and PARSONS R.F., 1977: Size class Analysis of coastal scrub and woodland, Western Port, Southern Australia. *Aust. J. Ecol.*, 2: 187-198.

HOPE, G.S. 1978: The Late Pleistocene and Holocene vegetational history of Hunter Island, north-western Tasmania. *Aust. J. Bot.*, 26: 493.

HUBBLE, G.D., 1951: A reconnaissance survey of the coastal heath country, North West Tasmania. *CSIRO, Division Report, Dept. of Soils.*

JACKSON, W.D., 1968: Fire, Air, Water and Earth - An elemental ecology of Tasmania. *Proc. Ecol. Soc. Aust.*, 3: 9-16.

MacPHAIL, M., SHEPHERD, R.R., BROWN, M.J. and JACKSON, W.D., 1975: THE NORFOLK AREA ENVIRONMENT STUDY, Tasventure Environment Centre, Devonport.

MESTON, A.L., 1934: Aboriginal rock carvings in Tasmania. *Antiquity*, 8: 179-184.

NICOLLS, K.D. and DIMMOCK, G.M., 1965: Soils. *in* Davies, J.L. (ed.): ATLAS OF TASMANIA, Lands and Surveys Dept, Hobart, 26-29.

SPECHT, R.L., 1970: Vegetation, *in* Leeper G.W., (ed.): THE AUSTRALIAN ENVIRONMENT, Fourth Ed. CSIRO.

SUTHERLAND, F.L., 1972: The geological development of the southern shores and islands of Bass Strait. *Proc. R. Soc. Vict.*, 85 (2): 135.

WENDELKEN, W.J., 1974: New Zealand experience in stabilization and afforestation of coastal sands. *Internat. J. Biometeor.*,18: 145-158.

WILLIAMS, E. and TURNER, N.J., 1973: Geological atlas 1: 250 000 series. SK 55-3, Burnie. *Explan. Rep. geol. Surv. Tasm.*

WILLIS, J.H., 1970: A HANDBOOK TO PLANTS IN VICTORIA, VOL. 1. FERNS, CONIFERS AND MONOCOTYLEDONS, 2nd ed., Melbourne University Press.

APPENDIX

PLANT COMMUNITIES OF MT CAMERON WEST

Numbers in brackets indicate the vegetation mapping units which contain these communities.

1. *E. viminalis* - *E. ovata* low-woodland (7)
2. *E. obliqua* woodland (2)
3. *E. nitida* woodland (7.9)
4. *Banksia marginata* open-woodland (4)
5. *Melaleuca ericifolia* closed-scrub (6)
6. *Leptospermum laevigatum* closed-scrub (6)
7. *Acacia sophorae* closed-scrub (7)
8. *Ulex europaeus* closed-scrub (6)
9. *Melaleuca spp. Leptospermum* spp. closed-heath (9)
10. *Calocephalus brownii* - *Olearia lepidophylla* low-shrubland (3)
11. *Tetragonia implexicoma* low-shrubland (2, 3, 4, 5)
12. *Lomandra longifolia* tussock-sedgeland (4)
13. *Restio complanatus* - *Lepidosperma filiforme* sedgeland (9)
14. *Lomandra longifolia* - *Scirpus nodosus* sedgeland (3, 4)
15. *Lepidosperma gladiatum* sedgeland (4)
16. *Leptocarpus tenax* sedgeland (9)
17. *Pteridium esculentum* closed-fernland (3, 4, 5)
18. *Poa poiformis* grassland (3, 4)
19. *Ammophila arenaria* - *Festuca littoralis* grassland (3)
20. *Stipa teretifolia* open-grassland (2, 3, 4)
21. *Distichlis distichophylla* grassland (4)
22. *Carpobrotus rossii* herbfield (1, 2, 3, 4)
23. *Aira caryophyllea* - *Vulpia bromoides* grassland (4)
24. *Plantago bellidoides* - *Solenogyne bellioides* herbfield (3, 4)
25. *Nablonium calyceroides* closed-herbfield (4)
26. *Salicornia quinqueflora* open-herbfield (2)

CHECKLIST OF SPECIES FOR MT CAMERON WEST

The nomenclature for species in the checklist follows Curtis (1963, 1967) and Curtis & Morris (1975) for dicotyledons, and Willis (1970) for monocotyledons and pteridophytes except where authories are given. Endemic species are prefixed by "e", and introduced species by "i" in the checklist.

Seven Tasmanian endemic species were found in the area:- *Restio monocephalus*, *Correa backhousiana*, *Leptospermum glaucescens* and *Lilaeopsis brownii* are fairly widespread and are recorded from a number of other State Reserves. *Nablonium calyceroides* is restricted to the west coast and has been recorded in the West Point and the South-West State Reserves. *Hibbertia hirsuta* is listed as common by Curtis & Morris (1975), but has been recorded only in the Freycinet National Park. *Plantago bellidioides* is not known to occur in any other State Reserve.

PTERIDOPHYTA

Schizaeaceae
Schizaea fistulosa

Dennstaedtiaceae
Pteridium esculentum

Polypodiaceae
Microsorium diversifolium

Azollaceae
Azolla filiculoides

Selaginellaceae
Selaginella uliginosa

Gleicheniaceae
Gleichenia dicarpa, Gleichenia microphylla

Lindsayaceae
Lindsaya linearis

Aspleniaceae
Asplenium obtusatum

Lycopodiaceae
Lycopodium deuterodensum

ANGIOSPERMAE : MONOCOTYLEDONEAE

Typhaceae
Typha angustifolia

Juncaginaceae
Triglochin procera

Potamogetonaceae
Potamogeton australiensis

Gramineae
Distichlis distichophylla, Poa poiformis, i *Poa annua, Festuca littoralis,* i *Holcus lanatus, Stipa teretifolia,* i *Lolium perenne,* i *Ammophila arenaria, Themeda australis,* i *Aira carryophyllea,* i *Vulpia bromoides, Spinifex hirsutus.*

Cyperaceae
Schoenus nitens, Scirpus cernuus, Scirpus nodosus, Scirpus inundatus, Scirpus spp., Baumea acuta, Baumea rubiginosa, Baumea tetragona, Gahnia grandis, Lepidosperma gladiatum, Lepidosperma filiforme, Lepidosperma elatius, Lepidosperma laterale, Gymnoschoenus sphaerocephalus, Carex appressa, Carex gaudichaudiana, Carex fascicularis

Lemnaceae
Lemna minor

Restionaceae
Restio tetraphyllus, Restio complanatus, e *Restio monocephalus R. Br., Leptocarpus tenax, Hypolaena fastigiata, Calorophus lateriflorus.*

Xyridaceae
Xyris spp.

Juncaceae
Luzula campestris, Juncus articulatus, Juncus caespiticius, Juncus maritimus, Juncus pauciflorus, Juncus pallidus, Juncus procerus

Liliaceae
Lomandra longifolia, Laxmannia sessiliflora, Dianella tasmanica, Dianella revoluta

Iridaceae
Patersonia fragilis

Orchidaceae
Acianthus exsertus, Pterostylis nutans.

ANGIOSPERMAE : DICOTYLEDONEAE

Ranunculaceae
Ranunculus sp.

Cruciferae
i *Cakile edentula*

Pittosporaceae
Pittosporum bicolor, Bursaria spinosa

Caryophyllaceae
i *Cerastium fontanum,* i *Cerastium glomeratum, Colobanthus apetalus,* i *Spergularia rubra*

Geraniaceae
Geranium sp, Pelargonium australe

Rutaceae
Boronia pilosa, e *Correa backhousiana, Correa alba*

Dilleniaceae
Hibbertia acicularis, e *Hibbertia hirsuta*

Violaceae
Viola hederacea

Tremendaceae
Tetratheca pilosa

Oxalidaceae
Oxalis sp.

Leguminoseae
Acacia verticillata, Acacia verticillata var. *ovoidea, Acacia suaveolens, Acacia mucronata, Acacia sophorae, Daviesia ulicifolia, Aotus ericoides, Pultenaea daphnoides, Pultenaea juniperina, Dillwynia glaberrima, Bossiaea cinerea,* i *Ulex europeaeus, Indigofera australis, Kennedia prostrata,* i *Trifolium spp.*

Rosaceae
Acaena novae-zelandiae

Cunoniaceae
Bauera rubioides

Crassulaceae
Crassula helmsii, Crassula sieberana

Droseraceae
Drosera pygmaea, Drosera spathulata, Drosera peltata.

Haloragaceae
Haloragis teucrioides, Haloragis micrantha, Myriophyllum amphibium, Myriophyllum elatinoides.

Callitrichaceae
Callitriche stagnalis

Myrtaceae
Leptospermum laevigatum, Leptospermum scoparium, Leptospermum lanigerum, e *Leptospermum glaucescens, Melaleuca squarrosa, Melaleuca squamea, Melaleuca ericifolia, Eucalyptus ovata, Eucalyptus viminalis, Eucalyptus obliqua, Eucalyptus nitida.*

Onagraceae
Epilobium sp.

Ficoideae
Carpobrotus rossii, Disphyma australe, Tetragonia implexicoma

Umbelliferae
Hydrocotyle sp. Xanthosia dissecta, Eryngium vesiculosum, Apium prostratum, e *Lilaeopsis brownii*

Caprifoliaceae
Sambucus gaudichaudiana

Rubiaceae
Opercularia varia

Compositae
Solenogyne bellioides, i *Bellis perennis, Olearia ramulosa, Olearia lepidophylla, Gnaphalium candidissimum, Gnaphalium luteo-album, Leptorhynchos sp. Helichrysum scorpioides, Helichrysum paralium, Calocephalus brownii,* e *Nabalonium calyceroides, Cotula sp. Senecio spp.* i *Cirsium sp.,* i *Silybum marianum, Leontodon leysseri, Sonchus megalocarpus*

Stylidiaceae
Stylidium graminifolium

Goodeniaceae
Se Selliera radicans

Lobeliaceae
Lobelia alata

Epacridaceae
Astroloma humifusum, Leucopogon parviflorus, Leucopogon australis, Leucopogon collinus, Leucopogon virgatus, Leucopogon ericoides, Monotoca glauca, Epacris impressa, Epacris lanuginosa, Sprengelia incarnata

Primulaceae
i *Anagallis arvensis, Samolus repens*

Convolvulaceae
Dichondra repens

Plantaginaceae
i *Plantago lanceolata,* i *Plantago coronopus,* e *Plantago bellidioides*

Chenopodiaceae
Chenopodium glaucum ssp. ambiguum, i *Beta vulgaris ssp. maritima, Salicornia quinqueflora.*

Polygonaceae
i *Rumex brownii,* i *Rumex acetosella, Muehlenbeckia adpressa.*

Lauraceae
Cassytha glabella, Cassytha pubescens

Proteaceae
Banksia marginata

Thymelaeaceae
Pimelea sp.

Euphorbiaceae
Amperea xiphoclada, Poranthera microphylla

Vegetation of Mt Cameron West

Urticaceae
Urtica incisa, *Urtica urens*

Casuarinaceae
Casuarina monilifera

Papers and Proceedings of the Royal Society of Tasmania, Volume 114, 1980.

(ms. received 10.10.1979)

A RECORD OF ABORIGINAL IMPLEMENT SITES IN THE QUEENSTOWN AREA, TASMANIA

by Keith D. Corbett
Geological Survey of Tasmania

(with one text figure)

ABSTRACT

CORBETT, K.D., 1980 (31 v): A record of aboriginal implement sites in the Queenstown area, Tasmania. *Pap. Proc. R. Soc. Tasm.*, 114: 35-39. ISSN 008-4703. Geological Survey of Tasmania, Department of Mines, Hobart, Tasmania, Australia.

Sites containing aboriginal flaked stone implements have been discovered in the Queenstown area, some 30 km inland from the west coast of Tasmania. The sites occur mainly on low ridge tops along the East Queen River and Reservoir Creek, and have been exposed only after removal of the original cover of rainforest and peat around the mine area. They suggest extensive inland habitation by the aborigines prior to the establishment of the now-widespread rainforest.

INTRODUCTION

Numerous aboriginal flaked stone implements were discovered by the author during geological mapping of the Cambrian volcanic rocks around Queenstown (145° 33'E. 42° 5'S) in 1975-76. Since there are no previous records of aboriginal habitation in the area (e.g. Sutherland 1972), the sites are herein recorded with a brief discussion of their significance. It must be emphasised that the site map (fig.1) is not meant to be comprehensive, but merely records those places where the author happened to find implements in the normal course of his mapping. There are undoubtedly many other sites in the area which have not been seen, and in adjacent areas which have not yet been mapped in detail. Mr. S.F. Cox (pers.comm.) has discovered more sites further north on the East Queen River. The site beside the access road to the Prince Lyell open-cut was drawn to the author's attention by Mr K.O. Reid of the Mt Lyell Company.

TOPOGRAPHY AND GLACIAL FEATURES

Queenstown is situated some 30 km inland from the west coast, at an altitude of 150 m. It lies at the western foot of the rugged West Coast Range, which locally rises to 1100 m on Mt Owen and 900 m on Mt Lyell. A low ridge at about 500 m (Philosophers Ridge) separates these two mountains, and a broad east-west valley cuts through the range just north of Mt Lyell (Comstock Valley) to connect with the King River valley to the east.

The country around the aboriginal sites represents the inland edge of an irregular erosion surface (Henty Surface) which extends westward to the coast. The surface has been heavily dissected to produce numerous small steep-sided ridges and hills with more or less flat tops. There are many small creeks and gullies which drain into the Queen River and its tributaries. The Queen River flows south for about 10 km before joining the King River, which cuts through the range and debouches into Macquarie Harbour.

Evidence from erosional and depositional features strongly suggests Pleistocene glaciation of the Queen River valley between the Mt Lyell Company mill and south of Lynchford, and of the valley of Conglomerate Creek. Evidence includes U-shaped cross-section, planed-off spurs, and deposits of coarse bouldery gravel "plastered" on the valley sides. The bouldery material, which occurs up to 50 metres above the present

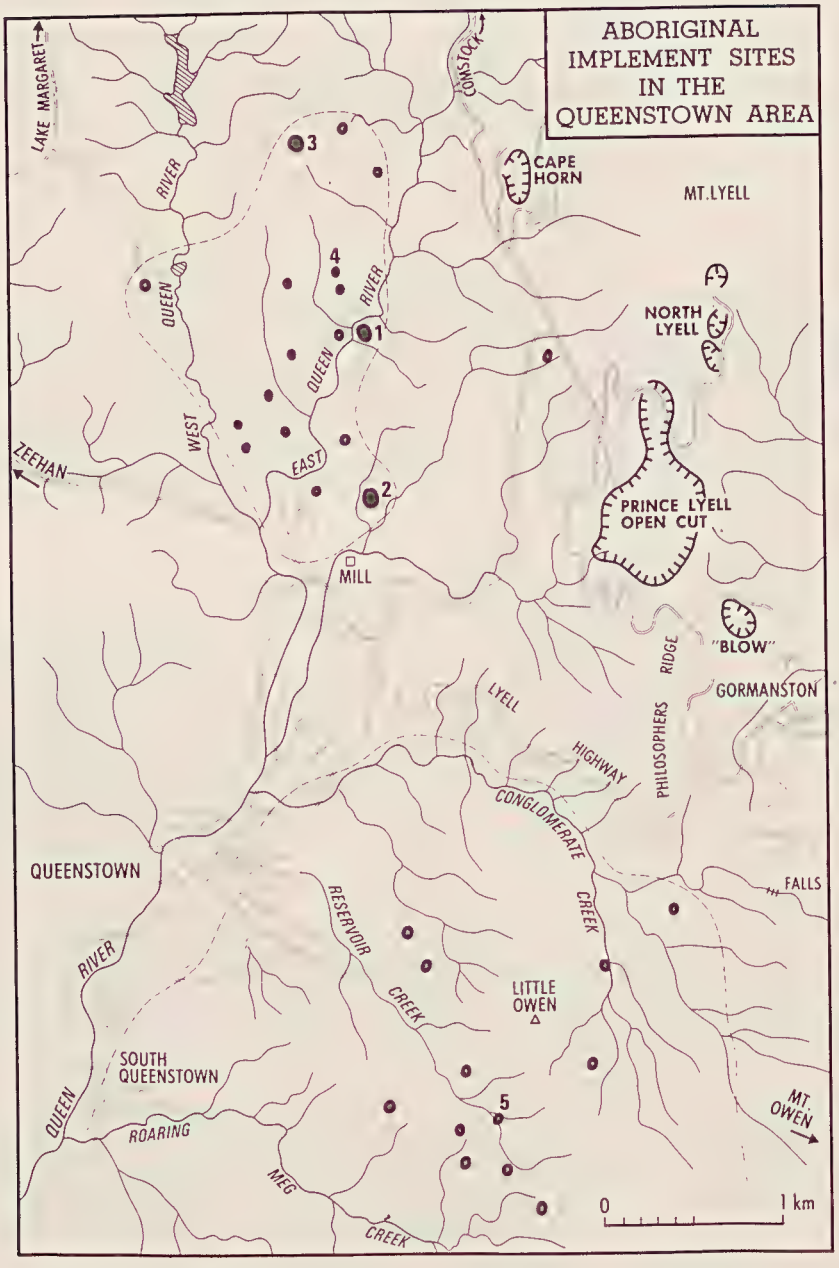


FIG. 1.- Map of aboriginal implement sites recorded in the Queenstown area. Large black dots indicate major sites. Numbers are referred to in text. Dashed line indicates approximate limit of detailed geological mapping by the author.

valley floor (Corbett, 1979), contains rounded blocks of Owen Conglomerate up to 1.5 m across, as well as irregular lenses of brown sandy clay with dispersed clasts. The deposits overlie weathered Gordon Limestone in the lower part of Conglomerate Creek and just west of the Mt Lyell mill, and in both areas the black limestone clays show considerable contortion. The highly disturbed (but still more or less in-situ) black clays at Conglomerate Creek are irregularly penetrated by gravelly material in places, probably due to glacial over-riding. A few remnants of similar bouldery material were noted in the middle reaches of the East Queen River, but evidence for glacial erosion in this area is not obvious.

Considerable stream dissection of the glacial topography appears to have occurred in Conglomerate Creek, resulting in a series of small overlapping spurs below the level of the original glacial valley floor. At least one of the aboriginal sites lies close to the present valley floor, suggesting the occupation post-dates the glaciation.

VEGETATION HISTORY AND SITE PRESERVATION

That the sites have been discovered at all is mainly a consequence of the lack of vegetation in the area. The original rainforest which blanketed all but the higher peaks in the area when white man first arrived was mostly killed off by sulphur fumes from the early pyritic smelting around the turn of the century. Clearing for timber, together with frequent bushfires, accounted for the rest (Kirkpatrick 1977 a, b). Frequent fires since those early days, and erosion of much of the soil cover, have prevented the re-establishment of the forest. The present vegetation consists of sparse colonizing shrubs, with scattered dense thickets, or is virtually non-existent.

The peat layer below the forest cover has been burnt and/or removed by the erosion consequent on the high rainfall, and much of the underlying soil has also been stripped off. The artifacts which remain, therefore, represent a lag deposit preserved on the flatter areas where runoff erosion has not been so effective. Their relationship to the original soil and peat layers is not known. Any original charcoal or other light organic material would also have been destroyed or removed.

The vegetation cover becomes considerably denser to the west and south of the recorded sites, so that recognition of sites in these areas would be much more difficult.

DESCRIPTION OF THE SITES

Of the 30 sites recorded, 18 lie to the north of Queenstown and are concentrated along the East Queen River, and 12 lie to the southeast of the township, mostly in the vicinity of Reservoir Creek. Most of the sites are on the flat crests of ridges, or on saddles, or on small flat areas above creek level. There are no significant natural caves or rock shelters in the area mapped. The majority of sites merely represent a few implements scattered over a small area, with an occasional core stone or rounded cobble. The artifacts are easily recognizable because they normally consist of non-volcanic rock-types (usually pink quartzite) which are exotic to the site. The implements show the typical flaked structure recorded from elsewhere in Tasmania.

Three major sites have also been identified. These contain many implements, usually scattered over an area of several hundred square metres, and appear to have been relatively major habitation sites. Site 1 (fig.1) is situated on a flat, partly scrub-covered area on the nose of a small ridge about 30 m above the East Queen River on its east bank. A quick survey of this site showed about 55 flaked stone implements (probably including some discard flakes), 22 core stone, 3 roundstones (pounders?), 1 flat stone, and numerous bits of worked vein quartz, scattered over the area. Site 2 is located on the top of a low bare ridge about 400 m north of the Mt Lyell Mill.

Several dozen flaked implements occur at this site, as well as core stones and round cobbles. Site 3 is located on the watershed between the East and West Queen Rivers, near an old tramway cutting. It contains several dozen implements and some core stones.

ROCK-TYPES USED FOR IMPLEMENTS

The rock types represented in the implements and core stones mostly indicate derivation from the Queenstown area. The most common rock is pink or white quartzite derived from rounded pebbles and cobbles which occur in the creek beds and in glacial (?) deposits fringing the major stream valleys. Many of these were derived as rounded clasts weathered out of the Owen Conglomerate (Cambro-Ordovician) on the adjacent mountains, although ultimately derived from the Precambrian area to the east. In some cases, river cobbles of silicified sandstone and fine conglomerate derived directly from the Owen Formation have been used.

A few implements made from fine-grained cherty volcanic rock were also noted, including some of banded volcanic hornfels. In only one case, however, at Site 4, did it appear that these were derived from an outcrop rather than from stream gravels. In this case, small fragments of hard cherty material occurring as clasts in a volcanic agglomerate had been worked. A few poorly-preserved bone fragments also occurred at this site.

The only implement rock type which was clearly exotic to the Queenstown area was one of black vesicular volcanic glass (tachylite) at Site 2. This material is only known in association with the Tertiary basalts of Tasmania, the nearest occurrence of which is some 50 km to the northwest in the Granville Harbour area.

Fragments of white vein quartz occurred at many of the sites, but as this material is almost ubiquitous in the area it was seldom possible to establish whether or not its occurrence was fortuitous. The vein quartz is derived from numerous veins up to a metre thick which intrude the acid volcanic rocks and which weather to produce a lag deposit which blankets many of the low hills and ridges in the area. The material is hard and fine-grained, but breaks into irregular-shaped pieces. Its abundance and ease of procurement suggests it was probably used by the aborigines, but there is no clear distinction between implements and the naturally-occurring fragments. Clear, well-formed crystals of quartz, up to a few centimetres long, occur in some of the veins. At least one of the sites (Site 5 near Reservoir Creek) was situated adjacent to a deposit of these quartz crystals, suggesting the natives may have quarried them for ornaments.

DISCUSSION

The presence of abundant flaked stone implements around Queenstown indicates that the area was frequented by the Tasmanian aborigines at some stage prior to the arrival of white man in Tasmania. It seems unlikely that the natives would have penetrated the dense rainforest which clothed the area, extending almost to the coast, at the time of white settlement, and there are no historical records of natives in the area. Hence the habitation sites may pre-date the establishment of the forest. The sites probably post-date the known glacial activity in the area, but no attempt has yet been made to date the glacial deposits.

The discovery of the artifacts was a fortuitous result of the removal of the vegetation and the peat layer from the area by the activities of the early miners. It seems highly likely that many other sites lie buried beneath the peat, rainforest and scrub in surrounding areas. If access to the Queenstown area was possible, there

seems no reason to suggest that the valleys further inland were not also frequented. Aboriginal artifacts have recently been discovered in Late Pleistocene cave deposits in the Florentine Valley in central Tasmania (Goede and Murray 1977). This area is now occupied by rainforest but was probably open savannah woodland at the time of aboriginal occupation, which was prior to the climatic warming and invasion of forest at about 11 000 years B.P. (Macphail 1975).

Part of the reason for aboriginal habitation in the Queenstown area may well have been the occurrence of mineral deposits. The weathered ironstone gossans covering some of the copper orebodies on Philosophers Ridge (e.g. The Blow) would have provided an abundant source of ochre, and there could well have been brightly coloured secondary copper minerals which were mined for ornaments.

ACKNOWLEDGEMENTS

Helpful comments from Dr E.A. Colhoun, Dr A. Goede and Mr Jim Stockton are gratefully acknowledged. The paper is published with permission of the Director of Mines, Tasmania.

REFERENCES

Corbett, K.D., 1979: Stratigraphy, correlation and evolution of the Mt Read Volcanics in the Queenstown, Jukes-Darwin and Mt Sedgwick areas. *Bull. geol. Surv. Tasm.*, 58.

Goede, A. and Murray, P., 1977: Pleistocene man in south central Tasmania: evidence from a cave site in the Florentine Valley. *Mankind*, 11: 2-10.

Kirkpatrick, J.B., 1977a: Native vegetation of the West Coast region of Tasmania. *In* Banks M.R., and Kirkpatrick, J.B. (eds) : *Landscape and Man - The Interaction between Man and Environment in Western Tasmania.* Proceedings of a Symposium organised by the Royal Society of Tasmania, 55-80.

_____, 1977(b): The impact of man on the vegetation of the West Coast region. *Ibid:* 151-156.

Macphail, M., 1975: Late Pleistocene environments in Tasmania. *Search*, 6: 295-300.

Sutherland, F.L., 1972: The classification, distribution, analysis and sources of materials in flaked stone implements of Tasmanian aborigines. *Rec. Queen Vict. Mus.*, 42: 25 pp.

Papers and Proceedings of the Royal Society of Tasmania, Volume 114, 1980.

(ms. received 16.10.1979)

DEMYSTIFICATION OF THE MERSEY BLUFF MARKINGS

by Peter Murray
Tasmanian Museum and Art Gallery, Hobart

(with one table, three text-figures and one plate)

ABSTRACT

MURRAY, P., 1980 (31 v): Demystification of the Mersey Bluff markings. *Pap. Proc. R. Soc. Tasm.*, 114: 41-48 (incl. one plate). ISSN 0080-4703. Tasmanian Museum and Art Gallery, Hobart, Tasmania, Australia.

The Mersey Bluff markings have been accepted as petroglyphs attributed to the Tasmanian aborigines despite well presented, concise published evidence to the contrary. The site is now a tourist attraction. Historical circumstances and the lack of an adequate natural explanation for the markings are largely responsible for this state of affairs. Recent geological findings indicate that the dolerite in which the markings occur, displays curviplanar and concentric jointing responsible for many features of the markings. Some characteristics of the markings are similar to those caused by plant exudates from roots or rhizomes which follow natural irregularities in the rocks.

INTRODUCTION

A.L. Meston (1932) reported the discovery of what were believed to be the first known petroglyphs in Tasmania. He considered the unusual markings on the surface of the dolerite to be conventionalized aboriginal engravings of an astounding assortment of natural entities including a snake, the head of a bird, a leaf and an abalone shell. Also there were geometric patterns "...circles. concentric circles, large ovals with smaller ovals set within and ovals each with a salient which bears a striking likeness to a specialized type of aboriginal stone scraper" (Meston 1932, p.14).

A paper in the same (1932) volume of the proceedings presented the conclusion by E.O.G. Scott that the markings are the result of natural, not human agencies (Scott 1932). Scott listed 19 serious objections to an anthropogenic origin for the features including a careful consideration of the shapes to which descriptive names were applied, comparison of them with known petroglyphs, supposed areal and geographic restriction of the markings and detailed observations on overly deep, overly complex narrow and undercut outlines of many of the figures. That paper should have laid the matter to rest, and undoubtedly would have, were it not for two factors. Probably the most damaging blow to Scott's appraisal of the site was Meston's subsequent, almost immediate discovery of unambiguously genuine petroglyphs at Mount Cameron West on Tasmania's northwest coast (Meston 1933; Rhys Jones, personal communication). This circumstance, in conjunction with Scott's weak explanatory proposition that lichens and 'pneumatological' differentiation of the dolerite were responsible for the spectacular intaglios, swirling lines and circles, appears to have given Meston a doubt from which he could benefit. Geologists were forced to discount Scott's hypothesis of pneumatologic differentiation because the Mersey Bluff dolerite is isotropic and totally lacks any evidence of flow layering (Hill 1965). The etching action of slow growing lichens alone in producing markings of the magnitude of the "abalone" (0.72 x 0.52 m greatest depth of groove, 58 mm) also seemed untenable. Since 1931, the markings have been listed as being at least possible rock carvings by many authors including Jones (1966), Lourandos (1970), Völger (1972), Sims (1977) and Plomley (1977). Werner, a consultant from UNESCO, visited the site in 1970 and pleaded for its preservation. On this basis a museum has been established on the site.

TABLE 1

Comparison of widths and depths of grooves from three Tasmanian rock-carving sites.

MERSEY BLUFF (DOLERITE)[1]

"Fish"		"Snake"	
Depth groove	*Width groove*	*Depth groove*	*Width groove*
N = 37	N = 37	N = 13	N = 13
$\bar{x}$ = 5.7 mm	$\bar{x}$ = 17.7 mm	$\bar{x}$ = 11.0 mm	$\bar{x}$ = 8.1 mm
s = 4.5	s = 6.4	s = 5.9	s = 2.7
r = 0.0-18.0 mm	r = 0.0-27.0 mm	r = 2.0-18.5 mm	5 = 5.0-15.0 mm
v = 78.6%	v = 36.0%	v = 54.1%	v = 33.8%

MT CAMERON WEST (CALCARENITE)[2]

"Circle"		"Emu Track"	
Depth groove	*Width groove*	*Depth groove*	*Width groove*
N = 4	N = 4	N = 5	N = 5
$\bar{x}$ = 15.7 mm	$\bar{x}$ = 23.0 mm	$\bar{x}$ = 18.9 mm	$\bar{x}$ = 24.0 mm
s = 3.0	s = 1.6	s = 1.7	s = 5.6
r = 13.0-20.0 mm	r = 21.0-25.0 mm	r - 16.5-21.0 mm	r = 18.0-32.0 mm
v = 19.0%	v = 7.1%	v = 9.3%	v = 23.4%

GREENS CREEK (SILICIFIED SHALE)[3]

"Typical Circle"		"Deep Circle"	
Depth groove	*Width groove*	*Depth groove*	*Width groove*
N = 4	N = 4	N = 4	N = 4
$\bar{x}$ = 6.2 mm	$\bar{x}$ = 48.2 mm	$\bar{x}$ = 10.7 mm	$\bar{x}$ = 48.2 mm
s = 1.5	s = 7.6	s = 2.7	s = 13.1
r = 4.0-7.0 mm	r = 38.0-56.0 mm	r = 8.0-14.0 mm	r = 37.0-66.0 mm
v = 24.0%	v = 15.0%	v = 25.6%	v = 27.1%

1. Data from Scott (1932).
2. Measurements from casts.
3. Data from Stockton (1977).

N = number in sample; $\bar{x}$ = mean; s = standard deviation, r = range; v = coefficient of variation $\left(\frac{100s}{\bar{x}}\right)$

Despite claims to the contrary (Sims 1977), the markings on Mersey Bluff are radically different from all other petroglyphs yet found in Tasmania (or anywhere else in the world). Because of this potentially great contrast in motif and style, positive acceptance or rejection of the markings as being anthropogenic has profound implications for Tasmanian and Australian prehistory.

THE MERSEY BLUFF MARKINGS

Nearly half a century has expired since Meston's description of the sites. Whatever feelings passed among the participants in the debate have long been forgotten, and the Mersey Bluff markings have since become a tourist attraction, complete with museum and souvenir shop. Had it not been for this final development, the question of authenticity of the markings might never have been raised again.

On making a transect of the bluff, one may observe that the markings are of a continuously varying nature, ranging from uniformly distributed, obviously natural joints to the more sporadic, isolated and variable expressions of the same phenomenon, where the rock surface had recently lain beneath the soil. This characteristic of the Mersey Bluff markings is foremost among Scott's formidable list of damning observations. Scott also drew attention to the extreme variability of the widths and depths of grooves in any single marking. Rock carvings elsewhere in Tasmania show considerably greater uniformity in this respect (Table 1). In addition, the grooves of many of the Mersey Bluff features are extremely narrow for their depth (for example 6 mm wide by 26 mm deep) and some grooves are undercut or flask-shaped in cross section (Scott 1932).

Evidence of how the grooves were made is lacking. There is no indication of pecking or hammering, in fact, most of the grooves are very smooth. Some grooves appear to be composed of deep, conjoined elliptical concavities, but these do not resemble marks produced by percussion. The hardness of the dolerite renders abrasion to depths of up to 50 mm and deep grooves with tight turning radii inconsistent with Tasmanian aboriginal technology.

While Scott's (1932) politely understated suggestion of selective bias in presenting the markings photographically isolated from similar non-descript examples has gone unheeded, some of the most ardent supporters of the human origin hypothesis have shown a genuine ambivalence as to the nature of certain markings. Even Meston (1932) stated that "occasionally the artist has made use of natural uneveness in the rock to make his design stand out more but cracks in the rock have not been used." At present, a popular concession is that many of the carvings could represent natural markings that have been "touched up" by aboriginal artists. Recent publications have also used a bold drawing of the Mersey Bluff "abalone" (Sims 1977, Volger 1972, Plomley 1977) which tends to simplify and actually modify the shape of this extremely complex feature. At any rate, an examination of the total range of markings easily demonstrates Scott's point: there are numerous "birds heads", "emus", "seals", and "abalones" but none of these is quite right. They have enclosed areas, extra lines or are connected to a series of nondescript markings of the same character.

CURVILINEAR AND CONCENTRIC JOINTING

It is not my intention to reiterate Scott's (1932) observations which adequately cover every aspect of the problem and upon which I cannot improve. The major shortcoming of Scott's paper is the mechanism responsible for the markings in light of their suspected non-anthropogenic origin.

In 1965, a geologist described some peculiar jointing patterns that he discovered at Mersey Bluff (Hill 1965). The jointing in the Mersey Bluff sill differs markedly

PLATE 1.- Photograph of "abalone" showing ridging adjacent to grooves.

from typical columnar jointing usually found in dolerite outcrops. Instead of sharply defined polygonal and linear joints, the exposed surface of the sill displays curviplanar, concentric, radial and bowtie joint traces occurring in different combinations and being manifested in different ways depending on their position on the Bluff. The heavily weathered portions of the Bluff reveal arcuate, closely-spaced cracks radiating from foci located between 1.5 and 8 metres apart. Foci in close approximation (1.5 - 3.0 metres) form clearly defined joint traces having a radial or bow-tie pattern. Foci spaced further apart (3.0 - 8.0 metres) tend to form less regular and more widely spaced interlocking festoons (Hill 1965, p.255). In hand specimens sawn off at right angles to joint planes the joint traces consist of fine curving lines ranging from approximately 10 mm to 0.25 m apart (fig.1).

In heavily weathered exposed portions of the Bluff, in and just above the splash zone, these joints form complex patterns composed of curves, radial fractures, ovals, polygonal figures with rounded edges, platy or wavy textures and irregular pits (fig.2) These exposed surfaces weather relatively rapidly due to a combination of processes that include exposure to frost, exposure to heat, water erosion, chemical weathering and probably salt crystal wedging, creating a complex network of grooves and cracks in the surface of the stone, all of which have their origin as fine, often microscopic joint traces formed by the accumulation of stress in the central zone of the sill and its subsequent explosive release (Hill 1965, p.262). A change in the nature and degree of weathering is evident on ascending the Bluff from about 10 m to 25 m above sea level. This portion of the Bluff was covered until recently with a soil mantle and vegetation. The largest and most spectacular markings occur within the 20 m contour.

Hill's description of structural features of the Mersey Bluff sill correspond with elements of which the so called carvings are composed (fig. 3). These basic structura elements form many geometric shapes that are usually associated with manmade markings. The most striking examples are chevrons, circles, spirals and oval figures (fig.4). Many of the markings combine a number of these elements.

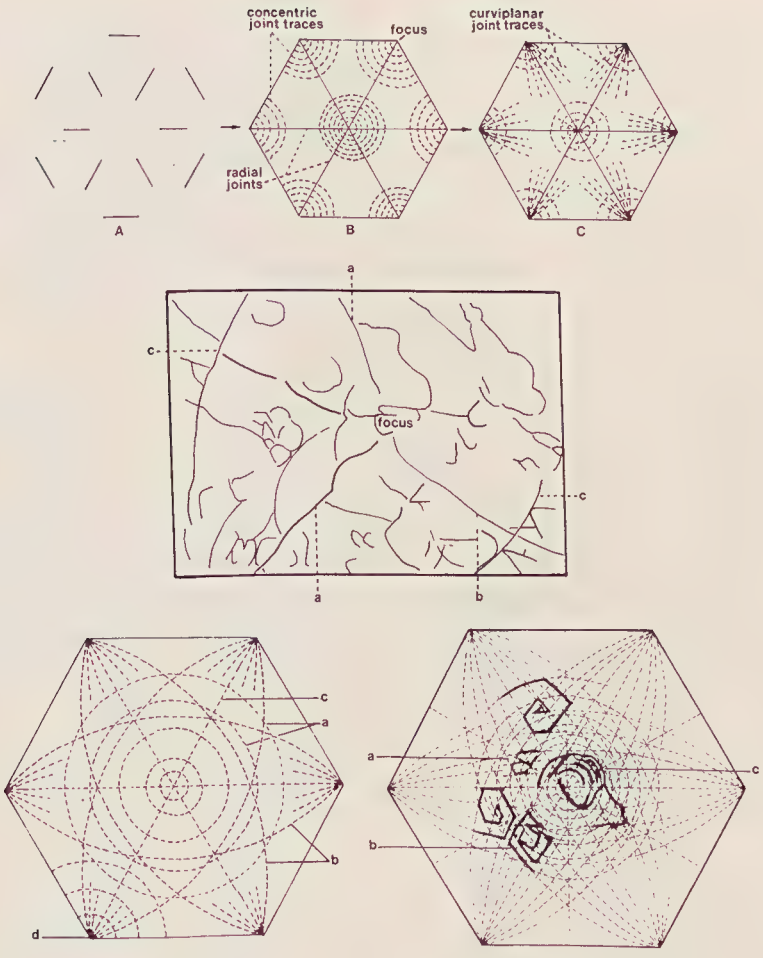


FIG.1.

Top. Origin of curviplanar jointing according to Hill (1965): (a) propagation of master columnar joints; (b) concentric fields of stress at foci; (c) propagation of curviplanar factures.
Centre. Top surface of angular pseudocolumn showing: (a) intersecting columnar joints; (b) curviplanar traces radiating from focus; (c) concentric polygonal joints (transecting curviplanars traced from a photograph in Hill 1965).
Bottom (Left). Master columnar joint with idealised fracture pattern superimposed: (a) concentric joints; (b) curviplanar joints; (c) radial or planar joints; (d) focus (modified after Hill, 1965).
Bottom (Right). Mersey Bluff markings superimposed on joint traces: (a) Meston (1932) Pl VII Fig. 5,6; (b) Meston (1932) Pl IV Fig.3; (c) Meston (1932) Pl VI Fig.3.
Other figures show development of spirals. Note for example, that (c) is composed of concentric, planar and curviplanar joints.

Demystification of the Mersey Bluff Markings

The "abalone shell" engraving is the most frequently figured example presumably because it is the best and largest of the supposed carvings (fig.5a). The abalone marking is always shown isolated from many similar adjacent markings which bear no resemblance to any known object but are of the same type as those comprising it. It is composed of chevrons, a spiral, pits, rippling marks, straight lines, and an irregularly subcircular outline (fig.5b,c). While the marking is highly irregular, it is not inconceivable that the figure has a crude hexagonal symmetry (fig.5b). The presence of the geometric elements in the marking appear to be the result of differential and selective weathering of a series of diamond or wedge shaped patterns formed by surface traces of curviplanar joints over which are imposed the concentric joints, the innermost of which always lie at right angles to curviplanars (fig.5d.). The spiral is therefore composed of combined curviplanar, planar and concentric joints. The margin of the marking is composed of concentric joints some of which are closely spaced and are interacting with curviplanar traces emanating from adjacent foci.

However, while the Mersey Bluff markings appear to conform to a peculiar type of jointing phenomenon, the specific agency responsible for selective erosion of the naturally occurring joint traces remains to be designated. Natural markings rivalling in complexity those at Mersey Bluff occur on granite outcrops on the Blue Tier in northeastern Tasmania (fig.6). These have several important features in common with the Mersey Bluff markings. Most of the markings are curvilinear, many are circular, some have deep narrow grooves, others are broad and shallow. Also like those of Mersey Bluff, many of the markings terminate by becoming increasingly shallower and broader (fig.5). The markings occur in apparently homogeneous granite boulders in continuously varying degrees of boldness. Their possible origin can be determined by examining boulders partially covered with vegetation. Lying in similar grooves are numerous examples of tree roots and rootlets. These are almost certainly responsible for the markings. In one case the stump and root of *Nothofagus cunninghamii* (myrtle was completely exposed and the relation of the entire root system to the network of grooves could be seen. Professor W.D. Jackson University of Tasmania, (personal communication) suggested that the fern *Phymatodes* may be responsible for the grooves, with trees such as myrtle following old markings made by that species. Whatever the sequence, roots and rhizomes are known to follow cracks because of better water supply and to obtain mineral nutrients and may well alter the chemical conditions in the rhizosphere by increasing acidity and thus slightly accelerate decomposition.

Many of the grooves in the rocks at Mersey Bluff are similar in cross-section shape and in other previously mentioned features suggesting that the markings are caused by the activity of tree roots that have invaded and eroded by chemical and physical means, segments of curviplanar, radial and concentric joints in the dolerite. As with the granite, decomposition of the feldspar fraction of the dolerite (which constitutes 40-50%) of the rock would lead to local collapse. Because the feldspars are large, and occur in clusters or small clots, these could be related to the localised pitting effect seen on the rock surface.

SUMMARY AND CONCLUSIONS

The combination of the two factors: 1) that of curviplanar, concentric and radial jointing and 2) the erosive and invasive action of roots, and/or rhizomes as shown by the Blue Tier example, particularly in its attack on feldspars is suggested to be sufficient cause for the Mersey Bluff markings.

ACKNOWLEDGEMENTS

I would like to thank D.R. Gregg for drawing my attention to P.A. Hill's paper on the Mersey Bluff dolerite and Jean Galloway who typed the manuscript.

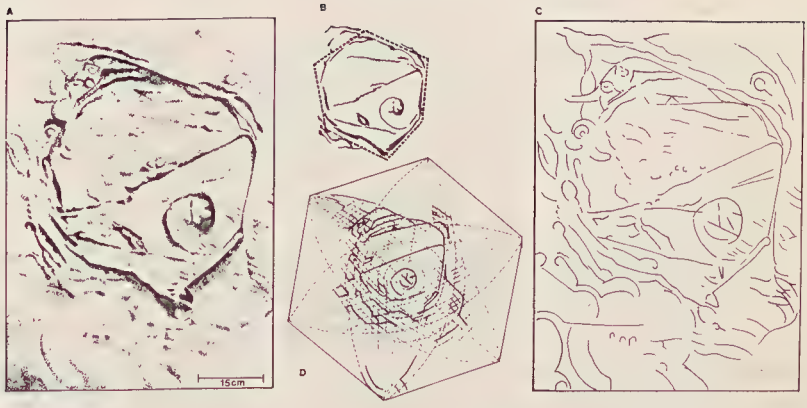


FIG.2.- Analysis of the Mersey Bluff "abalone" figure:
(a) drawing of "abalone" after Meston (1932);
(b) sketch of abalone showing crude hexagonal outline;
(c) major jointing pattern displayed by the figure;
(d) abalone figure superimposed on idealised joint traces.
The diagram suggests that the spiral is composed of concentric, planar and curviplanar joints. Note explanation of series of intersecting lines in right hand corner as merging curviplanar joints; other details of the figure can be similarly explained as being partially weathered and conjoined joint traces merging from several points of origin within a master column.

FIG.3.- Sketch of markings on granite in the Blue Tier near Lottah, North East Tasmania. These markings are caused by roots and or rhizomes of trees or ferns. A similar type of weathering is probably responsible for the differential expression of joint traces at Mersey Bluff.

REFERENCES

Hill, P.A., 1965: Curviplanar (radial, bow-tie, festoon) and concentric jointing in Jurassic dolerite, Mersey Bluff, Tasmania. *J. Geol.*, 73: 255-270.

Jones, R., 1966: A speculative archaeological sequence for northwest Tasmania. *Rec. Q. Vict. Mus.*, 25: 1-12.

Lourandos, H., 1970: A description of the aboriginal archaeological sites in Tasmania. In ABORIGINAL ANTIQUITIES IN AUSTRALIA. *Australian Aboriginal Studies* 22 Canberra, 35-38.

Meston, A.L., 1932: Aboriginal rock-carvings on the northwest coast of Tasmania. *Pap. Proc. R. Soc. Tasm.*, 12-19.

_____, 1933: Aboriginal rock-carvings in Tasmania Part II. *Pap. Proc. R. Soc. Tasm.* (1932): 1-6.

Plomley, N.J.B., 1977: THE TASMANIAN ABORIGINES. Adult Education, Hobart, Tasmania.

Scott, E.O.G., 1932: Preliminary note on supposed Aboriginal carvings at Mersey Bluff, Devonport. *Pap Proc. R. Soc., Tasm*, (1931): 112-129.

Sims, P., 1977: Variations in Tasmanian petroglyphs. In Ucko, P.J. (ed.): FORM IN INDIGENOUS ART. *Australian Institute of Aboriginal Studies*, Canberra: 429-438.

Stockton, J., 1977: Greens creek aboriginal engraving site. *National Parks and Wildlife Service, Tasmania, Occasional Paper* No.1: 1-13.

Völger, G. Von, 1972: *Die Tasmanier*. Franz Steiner Verlag GMBH Wiesbaden.

Papers and Proceedings of the Royal Society of Tasmania, Volume 114, 1980

(ms. received 23.1.1979)

REGIONAL GEOLOGY OF THE SOUTHERN FURNEAUX GROUP

by Joshua D. Cocker
Oregon State University, Corvallis, Oregon, U.S.A.

(with one table and four text figures)

ABSTRACT

COCKER, J.D., 1980 (31 v): Regional geology of the southern Furneaux Group. *Pap. Proc. R. Soc. Tasm.*, 114: 49-68 . ISSN 0080-4703. Department of Geology, Oregon State University, Corvallis, Oregon, U.S.A.

The Lower Palaeozoic Mathinna Beds are intruded and contact metamorphosed by sixteen Devonian, granitoid plutons in the southern Furneaux Group, northeastern Tasmania. Contact metamorphic aureoles range from 200 m to 2 km wide and on Clarke Island the metamorphic assemblage cordierite-andalusite-biotite-quartz-potash feldspar is preserved. Approximately 70 per cent by area of the granitoid terrain is composed of garnet and/or cordierite-bearing biotite granites (eight plutons), 20 per cent biotite granites (five plutons) including two altered plutons, and 10 per cent hornblende-biotite granodiorites (three plutons). The granitoids were intruded by widespread dolerite dykes of pre-Tertiary age. Cainozoic sedimentary sequences are thin and irregularly distributed. Mid-Tertiary sediments formed in lagoonal and shallow water marine environments have been reworked during the Quaternary by alluvial and aeolian processes. In the Rooks River tinfield the cassiterite, which was eroded from the pervasively altered Rooks River granite, is thought to be a lag deposit derived by reworking of the Tertiary sediments. Potential areas of exploration include the southern end of the Lee River valley near the strongly altered Rooks River granite and the alluvial fans north and south of the altered Hogans Hill granite pluton.

INTRODUCTION

This report summarizes the regional geology of the southern Furneaux Group (fig. 1), particularly the geology of the granitoid rocks. Some 20 islands in and south of Franklin Sound are considered with emphasis on Cape Barren and Clarke Islands. Sixteen granitoid plutons outcrop over some 60 percent of the southern Furneaux Group (fig. 2). The Lower Palaeozoic Mathinna Beds which are poorly exposed, especially inland, occur on Clarke and Badger Islands and in the northeast of Cape Barren Island where they are probably continuous with outcrops on Tin Kettle Island and Flinders Island. Marine, alluvial and aeolian Cainozoic sediments are poorly exposed in broad, low-relief, low altitude areas between granite mountains. Bedrock exposure is variable from excellent along some coastal sections to very poor, especially in the eastern half of Cape Barren Island where sand dunes and tea-tree marshes cover large tracts of ground.

Previous geological studies of the southern Furneaux Group include a comprehensive summary of the regional geology (Blake 1947), discussion of the mines and prospects (Keid 1949) and an outline of the geology, especially the Cainozoic sediments, in western Cape Barren Island (Coscombe 1965). Other contributions to the Tertiary geology of the southern Furneaux Group were by Johnston (1879), Crespin (1945) and Quilty (1971); and Sutherland (1973) discussed the Cainozoic geology and geomorphology of Flinders Island (fig. 1). Groves (1973) briefly described the distribution of different textural granitoid types on Flinders Island.

This work is based on reconnaissance field mapping and Figures 2, 3 and 4 are produced from aerial photo layouts without ground control. Consequently, the universal

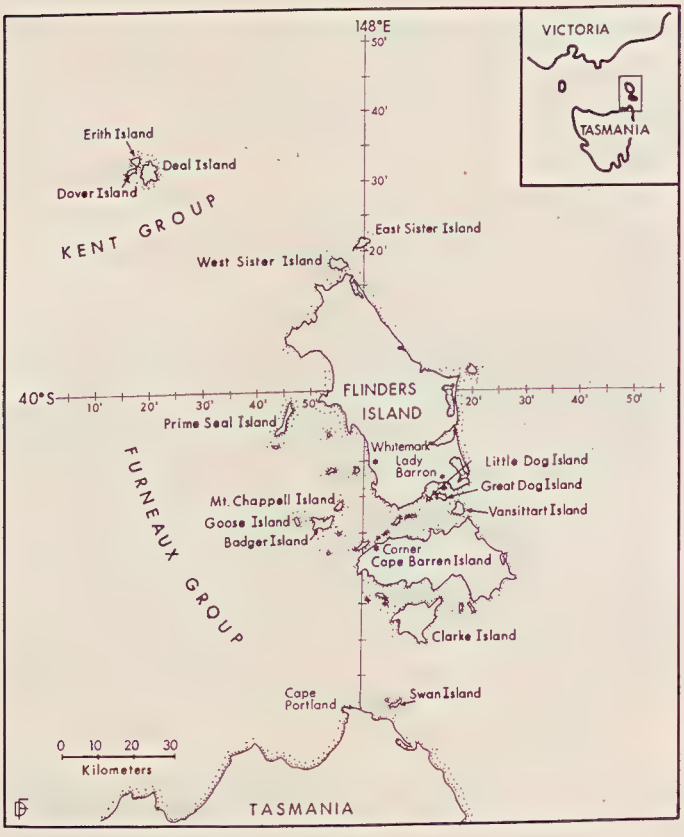


FIG. 1.- Locality map for the southern Furneaux Group.

grid co-ordinates used in this work are only approximate and strictly apply to the cited figures and those in Cocker (1977a). Samples referred to in this report are housed at the Geology Department, University of Tasmania.

MATHINNA BEDS AND CONTACT METAMORPHISM

Folded, low-grade regionally metamorphosed siltstones and sandstones which are contact metamorphosed by the granitoids are correlated with the Mathinna Beds in north-eastern Tasmania. These rocks are well exposed along the north coast of Cape Barren Island, on Clarke Island (fig. 2), and along the northern and southern coasts of Badger Island (fig. 4). Field measurements and aerial photograph interpretation of the structures indicate that the Mathinna Beds strike mainly in a northerly direction with shallowly plunging folds characterized by steep axial surfaces (vertical ± 20°), long planar limbs and sharp closures. Away from contact metamorphosed areas, slaty cleavage is present in most exposures. The change in fold vergence east and west of Puncheon Point may be interpreted as evidence for the disruption of the regional fold trends by the granitoid plutons. As there is excellent exposure, the regional structure of the Mathinna Beds could be clearly defined if detailed field studies were carried out.

Stratigraphic markers and fossils have not been found in these sediments, but the preponderance of sandstones and coarse siltstones indicates that they belong to the arenite-lutite sedimentary association found in eastern Tasmania (Banks 1962). Beds of sandstone rarely exceed 1 m in thickness and graded turbidite units with a variety of sedimentary structures are the most common bedded units. Sedimentary structures comparable to those at Scamander (Williams 1959) are well exposed along the north coast of Badger Island and along the north-east coasts of Clarke and Cape Barren Islands.

Numerous well-exposed coastal Mathinna Beds-granitoid rock contacts outcrop in the southern Furneaux Group. Clearly exposed contacts are noted in figures 2 and 4. The width of the contact metamorphic zones varies from 200 m to 2 km. In thin-section the

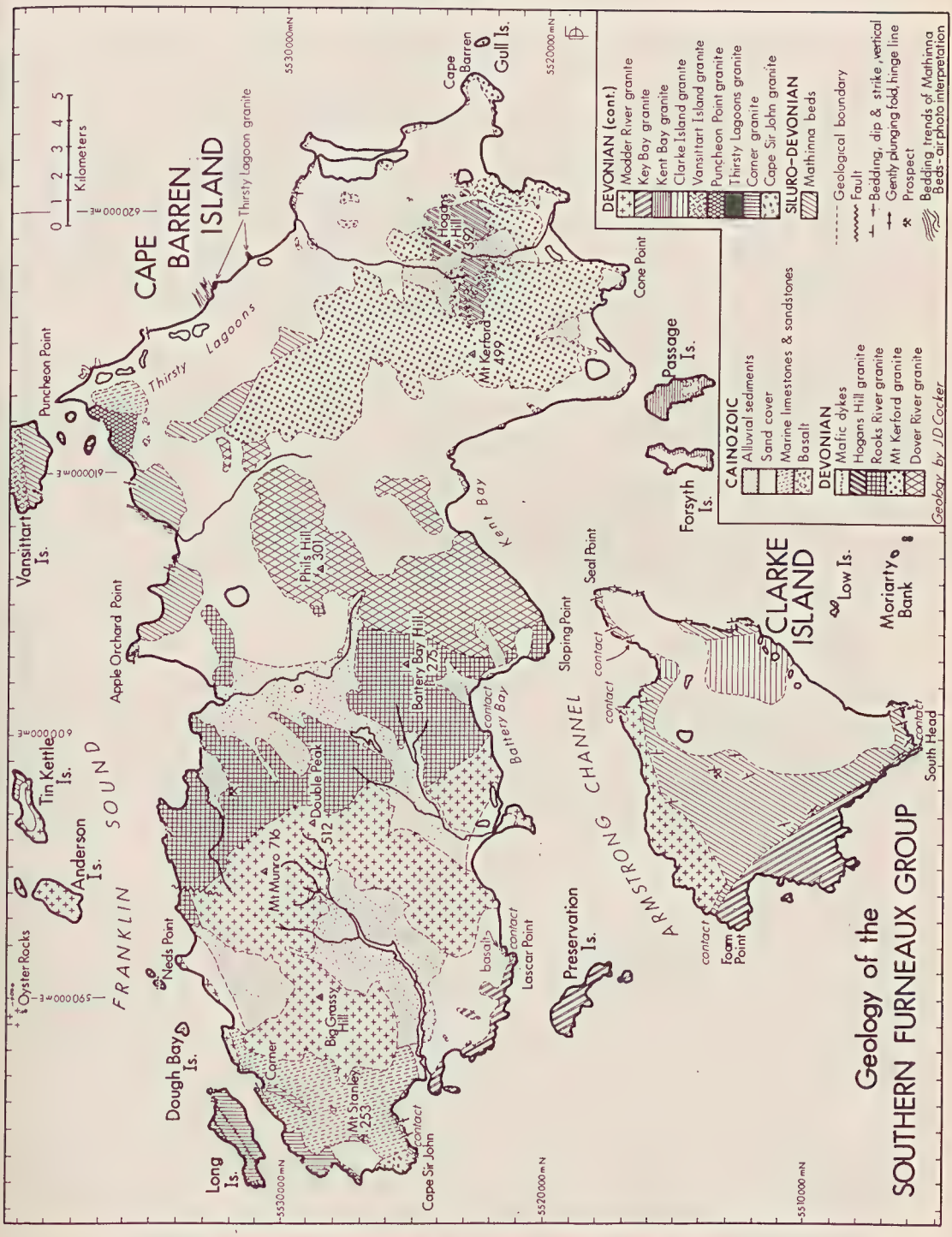


FIG. 2.- Regional geology of the southern Furneaux Group.

hornfels consist of fine-grained, equigranular quartz, feldspar and mimetic, red-brown biotite (43916, 43920). In spotted hornfels secondary white-mica and chlorite replace cordierite and/or andalusite. Sieve-textured white-mica up to 2 mm in width is common in some samples. The contact at South Head on Clarke Island is outstanding, as in well-exposed coastal outcrops primary cordierite, andalusite and biotite can be found in spotted hornfels up to 2 km from the Key Bay granite. As the granitoid-Mathinna Beds contact is steeply dipping, the wide contact-metamorphic aureole may reflect the intrusion of the Clarke Island granite, or an unexposed pluton, at depth. Also at South Head adjacent to the contact are several small outcrops of contact migmatite. The cordierite of the hornfels occurs as pseudo-hexagonal, cyclically twinned porphyroblasts with abundant inclusions of quartz and biotite and is surrounded by K-feldspar, andalusite and biotite (43301) or by a quartz-K-feldspar-biotite groundmass (43917) in the outer zone of the aureole. Unaltered contact metamorphic minerals besides biotite have not been recorded previously from north-eastern Tasmanian contact aureoles.

GRANITOID PLUTONS

On a broad scale, the larger granitoid plutons tend to be rectangular in shape with their largest dimension oriented north-south, parallel to the regional Mathinna Beds structure. This structural fabric is similar to that on the northeastern Tasmanian mainland. The plutons were intruded following the folding of the Mathinna Beds, but may have been affected by regional tectonic events which controlled the development of K-feldspar megacryst foliations. Although variably developed, the foliations are widespread and commonly trend north-south. The relatively steep, straight and sharp contacts and the lack of marked marginal deformation of the Mathinna Beds indicates that individual plutons were probably emplaced along fault controlled margins by roof-lifting. Minor stoping of the country rocks also occurred during emplacement. The sharp, transgressive contacts and lack of primary muscovite in the granites suggests that these plutons were emplaced at high levels in the crust, probably less than 6-9 km deep.

The granitoid plutons will be considered in three groups distinguished by their mafic mineralogy. Eight plutons are characterized by the occurrence of garnet and/or cordierite. Three small hornblende-biotite granodiorite plutons occur in the west of the southern Furneaux Group and biotite occurs as the single mafic silicate in five granite plutons, including the strongly altered Rooks River granite. The intrusive relations and common textural variants of each pluton are summarized in table 1. The main features of each pluton are discussed below. The petrogenesis of the granitoids is discussed in Cocker (1977a and in prep.).

MT KERFORD GRANITE

The Mt. Kerford granite, although well exposed around the southeastern coast of Cape Barren Island and Gull Island, has poorly exposed external contacts. Relative ages with the Kent Bay and Dover River granites are unknown, but the Mt. Kerford granite is intruded by the Hogans Hill granite and its associated dykes. The two textural variants of the Mt. Kerford pluton, a porphyritic phase and an equigranular phase, intrude each other and occur as inclusions one in the other. The porphyritic rock type forms approximately 50 percent of the outcrop on Cape Barren, Gull Island and south of the Hogans Hill granite. The northern half of the pluton which is poorly exposed is dominantly the medium-grained, equigranular rock type.

In hand specimen, quartz, K-feldspar, plagioclase and biotite are the main minerals with minor garnet and secondary white-mica. Garnet is a widely distributed accessory mineral (<0.01%), especially in the southern half of the pluton, and is also concentrated in spherical to lenticular masses. At FR/128.197, on the eastern side of Kent Bay, the garnet occurs in a crudely layered complex with a 0.3 to 0.5 m thick

TABLE 1

GRANITOID PLUTONS

Plutons	Intrusive Relations	Common Textural Variants
Garnet and/or cordierite-biotite granitoids:		
Mt. Kerford granite*	Intruded by Hogans Hill granite; intrudes Mathinna Beds	Medium grained, equigranular and porphyritic variants
Hogans Hill granite	Intrudes Mt. Kerford granite	Porphyritic granites and porphyries
Key Bay granite	Intrudes Mathinna Beds	Medium grained, equigranular granites
Modder River granite	Intruded by Rooks River granite; intrudes Mathinna Beds	Medium grained, equigranular and porphyritic granites
Dover River granite	Intruded by Rooks River granite; intrudes Mathinna Beds	Fine and medium grained equigranular granites
Clarke Island granite	Intrudes Mathinna Beds	Medium grained, equigranular granite
Kent Bay granite	Intrudes Mathinna Beds	Medium grained, equigranular granite
Puncheon Point granite	Intrudes Mathinna Beds	Fine grained, equigranular granite
Biotite granitoids:		
Rooks River granite	Intrudes Mathinna Beds, Dover River granite and Modder River granite	Wide variety of equigranular and porphyritic phases
Corner granite	-	Medium grained, megacrystic and equigranular granites
Thirsty Lagoons granite	Intrudes Mathinna Beds	Fine grained, equigranular granite
Mt. Chappell Island granite	-	Fine grained, equigranular granite
Vansittart Island granite	Intrudes Mathinna Beds	Wide variety, equigranular and porphyritic phases
Hornblende-biotite granitoids:		
Cape Sir John granodiorite	Intrudes Mathinna Beds	Medium grained, equigranular granodiorite
Badger Island granodiorite	Intrudes Mathinna Beds	Medium grained, equigranular and megacrystic granodiorites
Unicorn Point granodiorite	Intrudes Mathinna Beds	Medium grained, equigranular and megacrystic granodiorites

*No attempt is made in this report to establish formal lithological terms or form terms. Geographic names have been used to identify each pluton and may be retained following detailed mapping and further characterization. Lithological terms after Streckeisen (1975).

basal garnet-rich layer (up to 60% garnet) overlain by a relatively thin (0.1 m) biotite-rich layer. Flow sorting and possibly gravitational settling are proposed as the mode of concentration of the garnet. Approximately spherical garnet-rich masses

occur as elongated clusters, in some cases along rock type irregularities, and may be remnants of ruptured, layered complexes. Mafic inclusions are rare in the Mt. Kerford granite.

In thin-section garnet, quartz and biotite are early crystallized phases which were followed by plagioclase and K-feldspar. Common secondary minerals are white-mica after feldspars and chlorite after biotite. Garnet, biotite and plagioclase occur as euhedral to subhedral grains and most grain boundaries are relatively straight with little evidence for subsolidus deformation. The mineralogy for both textural variants is similar. Garnet dodecahedra include quartz, biotite, apatite, zircon, ilmenite, pyrrhotite and rutile. The proportion of inclusions tends to be erratic, but in 43252 zones of apatite-ilmenite and quartz-biotite inclusions mimic the outline of a single garnet grain. Pale-green biotite replaces the garnet along cracks, and commonly extends from the garnet into the surrounding K-feldspar. The early crystallized red-brown biotite booklets include apatite and zircon and may be intergrown with vermicular quartz around the booklet margins. The plagioclase composition of the Mt. Kerford granite ranges from An 40, with oscillatory zoning in most grains, to approximately An 20. The zoned portions are commonly flanked by a relatively wide sodic rim especially adjacent to K-feldspar. The perthitic K-feldspar includes all other phases and in the porphyritic rocks includes the groundmass, as do sodic mantles rimming zoned plagioclase. Quartz probably has a long crystallization history in this pluton as it is included in early formed garnet, is embayed in the porphyritic rocks and is commonly euhedral against K-feldspar in the equigranular rocks.

Cordierite pseudomorphed by intergrown white-mica is found in 43232, 43235 and 43242. In 43249, from a microgranitic phase of the porphyritic rock type (FR/249.223), light-green "spots", up to 5 mm in diameter, are composed of an isotropic light-brown compound partially replaced by white-mica and sea-green biotite. The amorphous compound has replaced anhedral cordierite which is intergrown with other phases in the rock.

The composition of the garnet in the Mt. Kerford granite and in other plutons discussed below is restricted to the following range - almandine 73 - 86%; pyrope 6 - 20%; grossular 3 - 5%; spessartine 3 - 5% (molecular). Similarly, the biotite in these plutons is rich in Fe and Al (Fe/(Fe+Mg) = 0.73 - 0.93; Al^{VI} = 0.72 - 1.33) (Cocker, in prep.).

HOGANS HILL GRANITE

The Hogans Hill granite is a small pluton composed of porphyritic granite and granite porphyries that crop out around Hogans Hill. The largest area of outcrop is wedge-shaped to the south and is capped by two small areas of the Mt Kerford granite. The hill to the west of Hogans Hill is composed of a series of shallowly south-dipping dykes joined by short vertical sections. Further to the northwest (near FR/155.242), similar north-south striking dykes, up to 30 m wide, outcrop and are comparable to smaller dykes intruding the Mt Kerford granite within a radius of five km from Hogans Hill. Contacts between the Hogans Hill granite and the Mt Kerford granite, although poorly exposed, are well defined especially those contacts with the equigranular Mt Kerford granite. Mafic inclusions were not observed in this pluton.

Red garnet occurs as a euhedral to subhedral, partially pseudomorphed phenocryst phase, up to 10 mm in diameter. Unlike other garnet-bearing plutons, concentrations of garnets are rare and the proportion of garnets is relatively low. The garnets tend to be surrounded by red-brown biotite, comparable to the phenocryst biotite and replaced by pale green biotite in cracks. Quartz, red-brown biotite, apatite, zircon and ilmenite are included in the garnets. The red-brown biotite occurs as individual booklets up to 5 mm in width and as aggregates of grains. The groundmass

biotite is altered to chlorite. Feldspar phenocrysts enclose groundmass grains and commonly form synneusis twins. The perthitic K-feldspar has been pervasively altered and is clouded with minute fluid (?) inclusions. The plagioclase is less altered than the K-feldspar, with zoned crystals commonly replaced by a net of white-mica. The plagioclase phenocryst compositions range from An 32 to An 10 whereas the groundmass plagioclase ranges from An 25 to An 10. The groundmass of the porphyries is aplitic and may be replaced by coarse-grained white-mica and quartz intergrowths.

KEY BAY GRANITE

The Key Bay granite outcrops on Clarke, Preservation and Cape Barren Islands, where along coastlines the contact relations are well exposed. On Clarke Island the Mathinna Beds form a narrow screen between this pluton and the Modder River granite in the north, and to the south along the coast the contact is steeply dipping and conformable with the Mathinna Beds structure. Stoped Mathinna Beds inclusions up to 100 m^2 are relatively common along this boundary in comparison with other Furneaux Group contacts. At South Head (ER/997.058) where the metamorphic aureole is up to 2 km wide, the contact is characterized by a well exposed predominantly stromatic contact migmatite, whereas further north (ER/988.070) the migmatite has a schollen structure. The Key Bay granite-Modder River granite contact is exposed as a straight (161°), sharp boundary at Lascar Point on Cape Barren Island. Unfortunately, the intrusive relations could not be established from this contact. Between Cape Barren and Clarke Islands this contact may have been displaced by a fault which strikes northeast along the Dyas Corner River valley.

The main rock type in the Key Bay granite is a coarse-to medium-grained, equigranular granite, but K-feldspar, megacryst-rich microgranites and porphyries are common on Cape Barren Island and are continuous along strike to the opposite coast on Preservation Island. From ER/988.219 to ER/995.215 along the coast, K-feldspar megacryst-rich rocks predominate and the strike directions of rock type boundaries, expressed as variations in the megacryst content and alignment of the megacrysts, approximately parallel the strike of the main contact at Lascar Point.

Garnet is a rare accessory phase in the porphyries of the Key Bay granite. In the equigranular granite the garnet occurs in irregular to rounded concentrations with up to 60 per cent garnet and biotite. These concentrations, up to 1 m in diameter, are common around Key Bay, are poorly developed at Lascar Point and were not observed on Clarke Island. Subhedral to anhedral garnets, up to 10 mm in diameter, are replaced by pale green biotite and enclose quartz, red-brown biotite, apatite, zircon and ilmenite. In thin-section, a red to colourless isotropic compound, which is replaced by sea-green mica and white-mica, replaces primary cordierite (43202). The amorphous compound enclosed remnant cordierite grains, quartz, red-brown biotite and andalusite. In this pluton the red-brown biotite occurs as clusters of subhedral grains in the equigranular rock variants and as phenocryst and groundmass grains in the porphyries. The biotite of the garnet-biotite concentrations is similar to the biotite of the equigranular rocks. The biotite includes zircon, apatite and Fe-Ti oxides and appears to be early in the paragenesis with garnet and quartz. Plagioclase grains have complex zoning patterns and range in composition from An 50 to An 10. Commonly the core is partially replaced by fine-grained white-mica, which also occurs as larger grains (up to 2 mm) after K-feldspar. The K-feldspar is perthitic, has poorly developed cross-hatch twinning and includes all other phases. The late paragenesis of the K-feldspar, its alignment and high modal abundance in some outcrops suggests that part of its crystallization may have occurred under subsolidus conditions.

MODDER RIVER GRANITE

The Modder River granite outcrops on Cape Barren and Clarke Islands. Along an

irregular eastern contact the Rooks River granite intrudes this pluton, but on other boundaries the contact relations are not apparent. Distinction between the Modder River and Corner granites is difficult, as the proportion and size of K-feldspar megacrysts vary in both plutons. In general the Modder River granite has a finer groundmass, but this was not clearly established along the north coast of Cape Barren Island. Included in the Modder River granite are exposures of granite on Dough Bay, Oyster Rocks, Tin Kettle and Anderson Islands where good outcrop reveals variation in grain size of both groundmass and megacrysts from island to island. In these localities, the contacts are steeply dipping and discordant to the Mathinna Beds structure, but on a small scale both conformable and disconformable, dilational and wedge-shaped dykes are exposed.

The main rock type of this pluton is a fine- to medium-grained, equigranular, biotite granite with a variable proportion (up to 30%) of K-feldspar megacrysts. The megacrysts range in size from 10 to 100 mm and are commonly aligned and segregated. Although a real variation in the proportion of megacrysts was established, distinct contacts between these areas were rarely found. Small-scale variations in the proportion of megacrysts occur in the Big Grassy Hill area. A characteristic field feature of this pluton is the widespread, sporadic development of biotite-rich layered complexes. These complexes occur as approximately equidimensional masses up to 40 m wide, with a fabric defined by the variation in biotite content, forming layers which are paralleled by tabular K-feldspar megacrysts. Most of the layering is subhorizontal, but in one steeply inclined, channel-like structure the K-feldspar grains and small inclusions are imbricated and suggest sedimentary-style deposition. Biotite-rich inclusions are relatively common in this granite, occurring as scattered individual inclusions and swarms associated with biotite layers. Many of the inclusions are similar to hornfelsed Mathinna Beds and tend to concentrate near the country rock contacts, especially along the north coast of Clarke Island. On Tin Kettle Island rectangular inclusions, up to 100 m long, occur adjacent to the contact. A planar vertically dipping foliation, defined by oriented masses of biotite grains, was noted on Clarke Island.

In thin-section the texture and mineralogy of the Modder River granite is comparable to that in other aluminous phase-bearing granites. Subhedral plagioclase and biotite are included in anhedral perthitic K-feldspar and anhedral quartz. The K-feldspar megacrysts are simply twinned and enclose the groundmass around their margins. The plagioclase has normal and oscillatory zoning with core compositions from An 35 to An 45 and sodic and myrmekitic rims. The plagioclase is partially replaced by fine-grained (0.01-0.02 mm), felted, white-mica and rarely chlorite and epidote. The biotite content of the Modder River granite is high and for some specimens exceeds 25 per cent. The maximum pleochroic colour of the biotite is red-brown, although minor pale-coloured secondary biotite, intergrown with quartz, occurs as a fringe on large biotite booklets which are adjacent to K-feldspar. Zircon and two generations of apatite are the principal inclusions in the biotite. The K-feldspar is variably clouded by fine-grained fluid inclusions which in some grains are spatially related to perthitic albite. Quartz has undulatory extinction and sutured grain boundaries. White-mica occurs as a secondary phase in plagioclase and rare grains up to 0.5 mm wide in K-feldspar are also interpreted as secondary in origin. Chlorite after biotite is variably developed.

Cordierite, as partially pseudomorphed anhedral to subhedral grains, has been identified in three samples (43068, 43070, 43068). These samples occur in the northern half of the pluton and cordierite occurs with garnets in a biotite-rich layered complex near the Mathinna Beds contact on Tin Kettle Island. Further mapping and petrography may reveal a more widespread distribution of these phases and differentiate rock variants in this pluton.

Joshua D. Cocker

DOVER RIVER GRANITE

Although the Dover River granite is well exposed along the southern coast of Cape Barren Island, poor inland exposure and lack of contact exposure means that both internal and external relations are poorly understood. The author was unable to locate the contact between the Dover River granite and the Rooks River granite with accuracy, because although there is good outcrop, similar rock types in both plutons are difficult to distinguish in hand specimen. Granite porphyry dykes which may be part of the Rooks River granite intrude the Dover River granite pluton. Two main rock types, fine-grained and medium-grained equigranular granites, are distinguished. North of Phils Hill the fine-grained rock predominates, whereas in the southern half of the pluton the medium-grained rock is predominant, with microgranites and porphyries as small, poorly defined masses. K-feldspar megacrysts and biotite define a cataclastic foliation in some northern outcrops. The proportion of biotite-rich inclusions is low but variable in this pluton, and discontinuous small-scale biotite layering is relatively common in areas of good exposure.

In hand specimen the characteristic feature of all rock types is the thinness of biotite booklets. The biotite is intimately intergrown with white-mica. In the medium-grained rock types a dominant textural feature is the inclusion of euhedral quartz grains in K-feldspar. This texture is also characteristic of the medium-grained Rooks River granite. The bulk of the plagioclase crystallized as zoned grains, with core compositions up to An 35, but a generation of smaller, unzoned, altered, oligoclase grains are common in the porphyries. The larger plagioclase grains are replaced by felted white-mica, whereas the second generation plagioclase is altered with minute fluid inclusions. The perthitic feldspar is similarly altered. The biotite has a maximum absorption colour of dark red-brown, and is variably altered to green biotite, and chlorite. The white-mica of the mica intergrowth is possibly a primary mineral, whereas coarse-grained, sieve-textured white-mica is a common secondary mineral, replacing K-feldspar. Rare biotite-quartz microinclusions comparable in lithology to the Mathinna Beds occur in this pluton.

Cordierite occurs in several textural variants of the Dover River granite. In the fine-grained granite rare cordierite is replaced by pale green biotite and white-mica. Cordierite, pseudomorphed by pale green biotite and white-mica, forms spherical 'spots' up to 10 mm in diameter in a small microgranite mass at FR/054.208 (43878). A microgranite dyke (43870) near the top of Phils Hill carries pseudomorphed cordierite as part of a granular texture.

CLARKE ISLAND GRANITE

The Clarke Island granite is a poorly exposed, vertically dipping dyke-like body conformable in shape to the regional Mathinna Beds structure. The close spatial association with, and many similar characteristics to, the Modder River granite suggests that this pluton may be part of the Modder River granite. Low Island to the south-east of the pluton is a granitoid rock and may be part of this pluton.

The Clarke Island granite occurs as massive outcrops of a medium-grained equigranular rock, with a poorly developed K-feldspar megacryst alignment which is most prominent at the contact exposures. At the north-eastern contact, layering parallel to the dyke walls has entrained numerous Mathinna Beds inclusions. The form of this layering is similar to that in the Modder River granite.

The petrography of the Clarke Island granite is similar to that of the Modder River granite except that the K-feldspar has well developed cross-hatched twinning. A second possible discriminating feature is the occurrence of small garnets in the Clarke Island granite. Garnets are included in plagioclase and K-feldspar and are partially

replaced by biotite. There is little evidence for euhedral margins in these grains, but in all other aspects (including composition) they are comparable to garnets in nearby plutons.

KENT BAY GRANITE

The Kent Bay granite is exposed on Forsyth and Passage Islands, and on isolated headlands along the eastern side of Kent Bay. Contacts with the Mt Kerford granite are not exposed. A penetrative mineral alignment defined by K-feldspar megacrysts and biotite is well developed on Forsyth and Passage Islands, striking 134 - 154°. Inclusion-swarms and individual inclusions are fairly common in this rock type; the swarms are often associated with biotite layering which is cut by the foliation. The inclusions may be divided into two groups, a biotite- and K-feldspar megacryst-rich hornfels and Mathinna Beds hornfels, both of which range in size up to 1 m in diameter. Remnants of an external Mathinna Bed contact in large stoped blocks of country rock are exposed on the eastern coast of Passage Island.

The main rock type of this pluton is a fine-to medium-grained, equigranular, biotite granite. The proportion of K-feldspar megacrysts rarely exceed 5 per cent. The mineralogy and petrography are similar to those of the Modder River granite except that the K-feldspar has incipient cross-hatched twinning. Also Mathinna Beds microinclusions are possibly more common in the Kent Bay granite than in the Modder River granite.

Garnets have been identified in two samples (43276, 43279) and pseudomorphed cordierite in sample 43276. In both samples the anhedral garnet is included in plagioclase and is partially replaced by pale-coloured biotite. The cordierite was subhedral in form and is completely pseudomorphed by pale green biotite and white-mica. In hand specimen the cordierite is comparable to isolated grains seen in the layered complex in the Modder River granite on Tin Kettle Island. The garnet in the Kent Bay granite has similar characteristics and chemistry to those in other garnet-bearing plutons.

PUNCHEON POINT GRANITE

The Puncheon Point granite is a poorly exposed, fine-grained, equigranular, biotite-cordierite granite. This pluton outcrops near Puncheon Point on Cape Barren Island and on nearby offshore islands and reefs where it is almost surrounded by country rocks. Complex outcrop patterns in the intertidal zone suggest that the roof region of the pluton is being exposed. Reconnaissance mapping indicates that this pluton extends to Flinders Island and the eastern half of Great Dog Island (fig. 1), although between this area and Puncheon Point a variably textured, pink to cream biotite granite outcrops on Vansittart Island and the western half of Great Dog Island. The Puncheon Point granite carries few inclusions and is distinguishable in hand specimen by aggregates of biotite, chlorite and white-mica after cordierite (up to 5%). The pseudomorphed cordierite is distributed as part of the equigranular rock fabric and as such is distinguished from the cordierite in other Tasmanian granitoids.

In thin-section, subhedral plagioclase occurs as large (up to 5 mm) zoned grains (up to An 41) and as clusters of small (up to 0.5 mm) grains included in the variably cross-hatched K-feldspar. Red-brown biotite, which is strongly chloritized, includes zircon and apatite and is also included in the K-feldspar. The K-feldspar is variably cloudy and this alteration may be correlated with the high proportion of white-mica which, with quartz, replaces the K-feldspar. The pseudohexagonal to anhedral cordierite is replaced by intergrown white-mica and pale sea-green biotite. Unaltered cordierite is replaced by intergrown white-mica and pale sea-green biotite.

Joshua D. Cocker

ROOKS RIVER GRANITE

This pluton includes a variety of altered rock types comparable with those in plutons associated with primary and secondary cassiterite deposits on the Tasmanian mainland. This similarity, and the occurrence of the largest secondary cassiterite deposits in the Furneaux Group in Cainozoic sediments surrounded and underlain by the Rooks River granite, suggests that this pluton has been the source for the cassiterite. Considerably more field work was carried out in this pluton in an attempt to identify specific source rocks, and further reduce the number of possible alluvial targets by defining areas of distribution of derived sediments.

The Rooks River Pluton is an irregularly-shaped body (fig. 2, 3) tapering to the south where it forms reefs off the northeastern corner of Clarke Island, and possibly extending as a narrow dyke-like body between the Mathinna Beds and the Dover River granite across the Dover River valley. This pluton intrudes the Modder River granite along an irregular, steeply dipping contact with a relief of some 500 m. The contact is offset by at least one and possibly two faults. At ER/970.245 and ER/947.324 the boundary between the Rooks River granite and the Modder River granite is well exposed, with short segments (up to 200 m long) of straight, steeply dipping contact, between the medium-grained, equigranular Modder River granite and a granite porphyry carrying micro-inclusions of the former rock type (43800). The porphyry may be a chilled margin to the medium-grained, equigranular Rooks River granite or a separate rock type which has intruded the contact. Porphyry dykes intrude the Modder River granite commonly up to 100 m from the contact. Adjacent to dykes and the main contact, the Modder River granite has been altered, displaying cream to pink feldspars. The eastern contact with the Dover River granite is poorly located and the medium-grained, equigranular

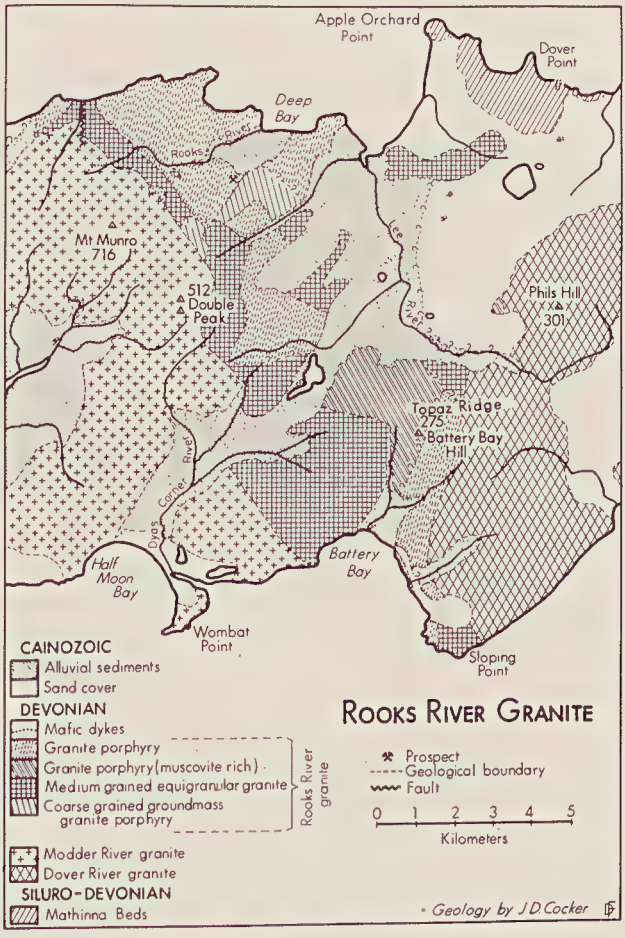


FIG.3.- The Rooks River granite.

granite shown (fig. 3) as part of the Rooks River pluton at Sloping Point may be part of the Dover River granite. The contact relationships are obscured by a variety of micro-granites and granite porphyries occurring as irregular bodies with gradational margins and as dykes.

This pluton is mapped as four major rock types (fig. 3), although the boundaries between these are mainly gradational, and intermediate rock types such as a porphyritic, medium-grained granite complicate relationships. Aplites, microgranites, porphyries and pegmatites are minor rock types. The main internal structural feature of the pluton is a band of the medium-grained rock type adjacent to the southwestern contact. Porphyries are the dominant rock type in the centre of the pluton, the contact between the porphyries and the medium-grained rocks, at least in the Rooks River area, being fairly straight and steeply dipping. On a large scale no reliable age relationships were established between these two main groups of rocks, but on a small scale both rock types intrude each other and occur as rounded inclusions in each other. Porphyry dykes commonly intrude both main rock types, have a variety of attitudes and rarely exceed 100 m in strike length. The fresher outcrops of all rock types are cream to pink-coloured while weathered outcrops are dark pink to red in colour.

The characteristic textural feature of this pluton is the equigranular grain size in both fine- and medium-grained rocks. Megacrysts in the medium-grained rocks and phenocrysts in the porphyries are commonly aligned with a north-south orientation. There is little biotite alignment and rare biotite layering is associated with minor pegmatites. Mafic inclusions are also rare in this pluton. Quartz veins are irregularly developed, steeply dipping and strike at 39 - 49°.

The granite porphyries are extremely variable in the phenocryst mineral content (5-90%) and in the proportions of different phenocrysts. Feldspars, clusters of embayed quartz grains and biotite booklets occur as prominent phenocrysts, with feldspars being the most common. White-mica is a widespread secondary phase in the porphyries and in the Battery Bay Hill area forms up to five per cent of the porphyry, replacing groundmass feldspars. The aplite and porphyry dykes are similar in hand specimen to the main granite porphyry. A distinguishing characteristic of the dykes is the occurrence of miarolitic cavities commonly associated with stringers of coarser-grained (up to 10 mm) minerals.

In thin-section, the feldspar phenocrysts enclose the groundmass which is composed of equidimensional grains with straight boundaries and is usually less than 1 mm in grain size. Phenocrysts rarely exceed 50 mm in length. In the coarse-grained groundmass porphyry (fig. 3), the grain size of the groundmass ranges from 1 to 3 mm. Plagioclase phenocrysts occur as normally zoned grains with core compositions in the range An 30 to An 35. Commonly the phenocryst cores are altered to fine-grained white-mica whereas their margins and the groundmass plagioclase grains are clouded. The groundmass plagioclase is albite-acid oligoclase, poorly-zoned and commonly deformed with bent, broken and wedge-shaped twins. The dustiness of the K-feldspar is variable, the smaller grains being generally more altered. The maximum absorption, pleochroic colour for the biotite in this granite is red-brown, but alteration to yellow-green biotite, chlorite and carbonate is widespread. The degree of alteration is variable, with the northern area of the pluton having less-altered biotites. The larger grains tend to be altered on their margins, whereas much of the groundmass biotite is completely altered. The biotite includes zircon, apatite and allanite. Allanite occurs as zoned and amorphous grains and is a common accessory in most samples in the Battery Bay Hill area. The porphyries carry white-mica after the groundmass feldspars and in the Battery Bay Hill area (fig. 3) 10 mm wide sieve-textured grains are well developed. Other minor phases in the porphyries are fluorite octahedra after plagioclase and rare tourmaline (43824). The rare occurrence of tourmaline in this altered pluton is in contrast with many altered plutons with widespread tourmaline on the Tasmanian mainland.

Although the medium-grained rock type is equigranular, the texture is more interlocking than in the porphyries, as K-feldspar includes all phases. The inclusion of subhedral to euhedral quartz in the K-feldspar is characteristic in hand specimen. Most mineralogical characteristics of the medium-grained rocks are similar to those of the granite porphyries. Two generations of plagioclase grains are not clearly identifiable, but core compositions are similar and range from An 35 to An 40. Patchy zoning is also common in some cores.

Miarolitic cavities are relatively common in the Rooks River granite. They occur up to 2 mm in diameter in the aplitic and porphyry dykes and form up to five per cent of the rock (43811). In thin-section, cavities have been found in the typical granite porphyries, in the coarse-grained groundmass porphyries and in the medium-grained granite. Commonly triangular in shape, the cavities are bound by quartz and feldspar crystal faces and are composed of amorphous material which may be replaced by axinite or chlorite.

CORNER GRANITE

The Corner granite is a medium- to coarse-grained, megacrystic granite exposed along the coast near the Corner settlement and around Long Island. The contact between this pluton and the Modder River granite was not located in this work. Both plutons have similar characteristics although the Corner granite tends to be coarser grained and carry more K-feldspar megacrysts. The contact between this pluton and the Cape Sir John granodiorite is not exposed.

In outcrop the Corner granite is heterogeneous with well-developed, short biotite layers, common aplite-pegmatite dykes and pegmatite pods, widespread tourmaline nodules and a high proportion of mafic inclusions. In many outcrops the K-feldspar megacrysts are aligned (129 to 174^{o}) and commonly parallel the steeply dipping biotite layers. On Long Island an 80 m long, layered complex is composed of biotite and parallel K-feldspar megacrysts, similar to the layered complexes in the Modder River granite. The short biotite layers are commonly cross-cutting and in some cases resemble sedimentary cross-bedding. Southwest of the Corner, mafic inclusions, some of which resemble the Mathinna Beds, are aligned in the K-feldspar foliation. The tourmaline nodules tend to occur in irregularly spaced clusters. Tourmaline is also a component in the pegmatites and is fairly common along joint planes in the granite. Further evidence for the activity of a fluid phase is shown by the intensely altered, red granite at ER/862.307. In outcrop over some 50 m^2 all the phases of this rock are altered and replaced by chlorite, epidote and fluorite. In thin-section the Corner granite resembles the Modder River granite.

THIRSTY LAGOONS GRANITE

This rock type is poorly exposed on two rocky points and offshore rocks on the northeastern coast of Cape Barren Island. The contact with the Mathinna Beds is not exposed, but small folds adjacent to the contact may be related to the intrusion of the granite. The Thirsty Lagoons granite is a fine-grained, equigranular, biotite-muscovite granite. The muscovite may be secondary in origin, after cross-hatched K-feldspar. The K-feldspar is slightly altered, and in contrast to most other Tasmanian granitoids the plagioclase is densely clouded with minute inclusions.

MT CHAPPELL ISLAND GRANITE

The Mt Chappell Island granite is well exposed around the northern and eastern coasts of Mt Chappell Island (fig. 4). The contacts with the Badger Island granodiorite were not examined. The Mt Chappell Island granite is a uniformly fine-grained, equigranular, biotite granite. Muscovite aplites intrude this pluton and

the Badger Island granodiorite.

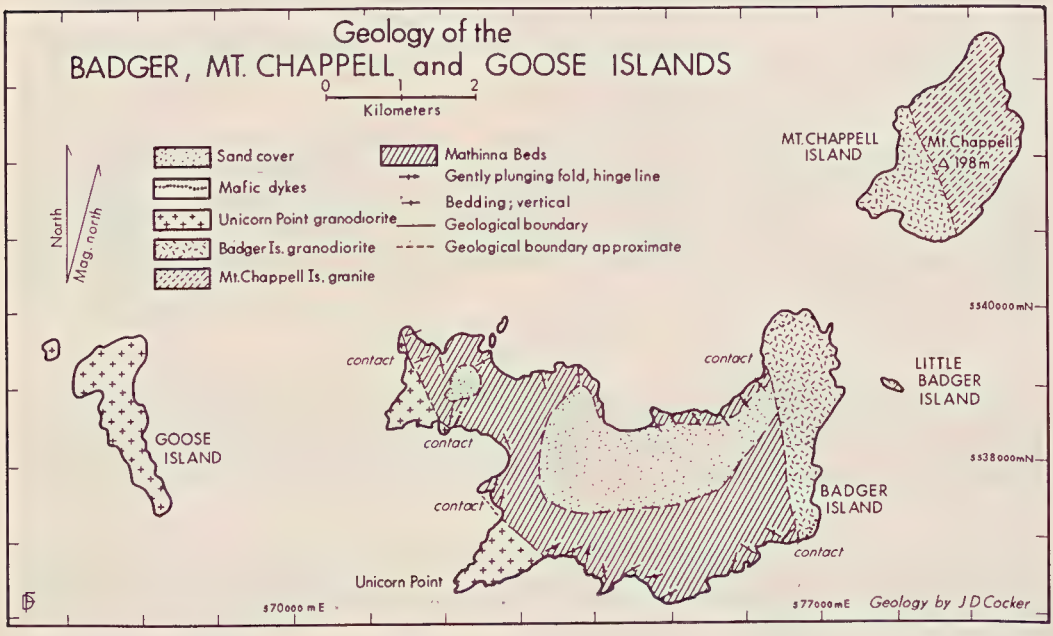


FIG.4.- Geology of the Badger, Mt Chappell and Goose Islands.

VANSITTART ISLAND GRANITE

The Vansittart Island granite is exposed on Vansittart, Great Dog and Little Dog Islands at the northeastern end of Franklin Sound (fig. 1, 2). This pluton is composed of a variety of cream to pink granites with a wide range of textures comparable with those of the Rooks River granite.

CAPE SIR JOHN GRANODIORITE

The Cape Sir John granodiorite is well exposed as massive foliated coastal outcrops on southwestern Cape Barren Island. The contact with the Corner granite is not exposed. The eastern Mathinna Beds contact is exposed as a conformable structure. The Mathinna Beds are indurated spotted hornfels, laced with quartz veins, and have been intruded by a pipe or pod-like mass of granodiorite with abundant inclusions which are similar to inclusion rafts in the main body of the granodiorite. Separate inclusions, and those in rafts up to 50 m long, are biotite-rich mafic rocks some of which are Mathinna Beds and others of deep, presumably relict, origin. The cataclastic foliation, bearing 149-164°, is enhanced by elongate inclusions aligned in the plane of the foliation. An irregular cross-cutting system of chloritic, cataclastic joint zones is well developed in most outcrops.

In hand specimen, the foliation is prominent with aligned biotite masses and mosaics of felsic minerals. The granodiorite is medium-grained with a variable

K-feldspar megacryst content. The megacrysts are commonly aligned in the foliation. The hornblende content of this rock type is less than one per cent. In thin-section the deformation is seen in kinked and recrystallized biotite and bent, broken and wedge-shaped twins in the plagioclase. Kink bands and healed kinks in the biotite are marked by ragged lines of inclusions and recrystallization into mosaics of smaller grains around the margins of the larger biotites. The quartz in the granodiorite is composed of grain mosaics in which individual grains have straight extinction and rare triple point boundaries. The static annealing indicated by quartz and biotite recrystallization was possibly caused by younger intrusions. The maximum absorption colour of the biotite is dark greenish-brown to red-brown and is comparable with other Tasmanian granodiorites. Chlorite and white-mica are secondary products after biotite and feldspars, respectively. The K-feldspar is somewhat dusty and includes all other phases. The plagioclase subhedra are complexly zoned with normal and oscillatory zoning sequences and albitic rims. Core compositions up to An 45 are common. Accessory minerals include apatite, zircon, sphene and orthite.

BADGER ISLAND GRANODIORITE

The Badger Island granodiorite (fig. 4) is exposed in the northeast of Badger Island and southwest of Mt. Chappell Island. On Badger Island both country rock contacts are well exposed and similar to the southeastern contact of the Cape Sir John granodiorite. The inclusion-rich intrusions isolated from the main body of the granodiorite are well exposed at the southeastern contact. These structures, 20 to 40 m wide, are composed of up to 60 percent country rock inclusions associated with curved biotite layering. The occurrence of 1 m long 'pods' of altered granitoid with miarolitic cavities and tourmaline suggest that these structures at some stage carried a high fluid content. Many of these features are comparable to those found along contacts in the Sierra Nevada Batholith (Moore and Lockwood 1973). They have not been recorded from other Tasmanian granitoid rock contacts.

In both hand specimen and thin-section, the Badger Island pluton is similar to the Cape Sir John pluton and both areas may belong to the same mass. The foliation (164-180°) on Badger Island is less developed than at Cape Sir John and the proportion of K-feldspar megacrysts may be higher on Badger Island. Annealed quartz grains were not noted in thin-section in the Badger Island granodiorite. Accessories for both rocks are similar.

UNICORN POINT GRANODIORITE

The Unicorn Point granodiorite is exposed in southwestern Badger Island and Goose Island. Extensive country rock contact exposures on Badger Island are transgressive on a large scale. On a small scale both conformable and disconformable structures are exposed. Mathinna Beds inclusions are relatively common in this rock type and inclusion swarms occur near the contacts. A variably developed K-feldspar megacryst foliation can be found in most outcrops. In two locations northeast of Unicorn Rocks rhythmic biotite layering in a 1 m thick sequence is well exposed over 50 m. This layering has been displaced by a healed fault which cannot be traced beyond the biotite layers.

The Unicorn Point granodiorite is a medium-grained, megacrystic, biotite granodiorite with rare hornblende grains. The biotite booklets in thin-section have a maximum absorption colour of dark red-brown and are included with all other phases in the K-feldspar. The biotite and plagioclase show little evidence of deformation and quartz mosaics are rare. The quartz is subhedral against K-feldspar and in most thin-sections is clearly embayed. Other features which allow distinction from the Badger Island granodiorite are the higher proportion of relatively perthitic K-feldspar and the coarser grain size.

GRANITE PORPHYRY DYKES

Some 20 granite porphyry dykes of variable orientation (15-104°, 152°) intrude the Modder River, Rooks River, Dover River and Kent Bay granites and the Mathinna Beds in central and eastern Cape Barren Island. The predominant mafic mineral is chloritized biotite, but some phenocrysts may be chloritized hornblende. These felsic porphyries outcrop as dykes up to 100 m long and 2 m wide, and in one locality near Battery Bay Hill have a cylindrical jointing pattern oriented along the dyke. A characteristic feature of some dykes is a spherulitic groundmass. The spherulites, composed of feldspar and quartz, occur in a variety of shapes and are commonly nucleated around embayed felsic phenocrysts. Other dykes have an aplitic groundmass and all samples have variable carbonate, epidote and sericite alteration.

MAFIC DYKES

Two generations of mafic dykes intrude and granitoid rocks and the Mathinna Beds of the Furneaux Group and eastern Tasmania. Cocker (1977b) has documented these dykes in the St. Helens area, where the spessartites are possibly related to the Cretaceous appinite suite at Cape Portland (fig. 1) (Jennings and Sutherland 1969) and the tholeiitic quartz-dolerites are thought to be pre-Permian in age, although some of the dykes may belong to the extensive Jurassic dolerites. The dolerites are widely distributed in eastern Tasmania and extend to the Hogan Islands (Hope *et al.* 1974) near Victoria. Several reports discuss the distribution of the dolerites including McNeil (1965), Groves (1972, 1977) and Jennings (1977). Blake (1947) located many dolerites especially in the Franklin Sound area and this work has extended their distribution (fig. 2, 4).

In the southern Furneaux Group, the dolerite dykes have a northeasterly strike and are not confined to particular granitoid plutons. Although most of the dykes occur between Cape Barren and Flinders Islands, isolated dykes occur in Battery Bay and in southwestern Clarke Island. Also more dykes may occur in the Mathinna Beds than those shown in figure 2, as these structures are commonly parallel to the bedding and are superficially similar in appearance to the thickly-bedded sediments. Coastal outcrops of the dolerites commonly exceed 100 m in length and rubble exposures can be traced for 3 km. Dyke widths vary from several millimetres to 10 m. In coastal exposure the dolerites occupy tensional fractures in the granitoid rocks and commonly wall irregularities may be matched across the dykes. Post-crystallization movement can be inferred from intense veining and slickensided joint surfaces in some dykes. Narrow zeolite- or carbonate-bearing veins occupy joints in dykes, and at Lady Barron on Flinders Island (fig. 1) a dyke is cut by a 5 cm wide, altered oligoclase, and chloritized biotite-bearing vein (43943) which does not extend beyond the margin of the dyke. These veins may be residual fluids from the crystallization of the tholeiitic magma.

In hand specimen the ophitic texture is preserved away from chilled margins, in grain sizes up to 5 mm. Porphyritic dolerites with plagioclase phenocrysts are rare and chlorite amygdales are widespread, but variably developed. In some dykes inclusions of granitoid rocks are common. The primary phase assemblage of labradorite, titanaugite, skeletal Fe-Ti oxides and minor pyrrhotite is variably altered to chlorite, epidote, calcite, amphibole, biotite and rarely prehnite after plagioclase phenocrysts.

Only one lamprophyre dyke carrying hornblende and biotite in an idiomorphic groundmass was identified near Puncheon Point. In hand specimen the mafic phenocrysts clearly distinguish this rock from the dolerites.

Joshua D. Cocker

TERTIARY SEDIMENTS AND BASALT

Calcarenites crop out poorly over a wide area in western and northeastern Cape Barren Island, and erratically in the centre of Badger Island. Quilty (1971) has dated the western Cape Barren Island sediments and a small outcrop on Preservation Island as Miocene. The eastern Cape Barren Island and Badger Island calcarenites may not be their stratigraphic equivalents. The calcareous, mollusc-rich sands overlying a basalt outcrop at Lascar Point on Cape Barren Island, opposite the Preservation Island locality, may be of a similar age, but post-basaltic sediments on Flinders Island are tentatively dated as Pliocene-Pleistocene (Harris 1965). The western Cape Barren Island calcarenites were deposited under shallow, marine conditions (Quilty 1971).

A variety of lithologies from the deeper levels in the Rooks River alluvial workings include carbonaceous and pyritic sediments which suggest a coastal lagoonal environment of deposition, in contrast to the sedimentological environment of the calcarenites nearby. The lagoonal sediments have been dated as Oligocene-Lower Miocene (Harris 1965) and in the Rooks River valley have a thickness of up to 59 m (Standard 1972). Based on the distribution of basement outcrops similar thicknesses of Tertiary sequences may occur in the nearby Lee River valley and possibly the Dyas Corner River valley.

Alkali-olivine basalt is exposed on a small tidal platform east of Lascar Point.

QUATERNARY SEDIMENTS

Quaternary sand cover and alluvial sediments are widespread in the low-lying, poorly-drained country in central and eastern Cape Barren Island, and eastern Clarke Island (fig. 2). Sand cover includes parabolic dunes up to 3 km long and sandy soils composed of coarse-grained felsic minerals from weathered granitoids. The alluvial sediments of the Rooks River, Lee River and Dyas Corner valleys are usually less than 9 m thick and overlie Tertiary sediments. A disconformity between Quaternary sand and gravel and Tertiary sediments is exposed in the Rooks River alluvial workings, in which the younger sediments occur above and as infillings in mud cracks in the Tertiary rocks. To some extent the Quaternary sediments in the larger valleys are probably wind-sorted lag deposits resulting from the removal of finer grain sizes to the dune fields in the east. Most streams have limited accumulations of alluvial material with the exception of the Modder River valley, and alluvial fans north and south of Hogans Hill. The alluvial sediments in the Modder River valley are widespread although usually less than 20 m thick. Bedrock outcrops occur in numerous streams. There are no extensive alluvial sediments on Clarke Island.

The elongate, parabolic dunes have westerly wind vectors similar to lunette dunes around deflation lakes in central and eastern Cape Barren Island and north-central Clarke Island. Two major dunes in the Thirsty Lagoons area climb low hills and have well preserved hairpins. These dunes are unrelated to the modern coastal parallel and blowout dunes as their sand appears to have been derived from the alluvial plains in the centre of the islands, rather than from the coastal areas.

MINERALIZATION

Primary cassiterite mineralization in the southern Furneaux Group is restricted to minor occurrences. These include a miarolitic cavity-rich aplite carrying minor cassiterite and molybdenite in the Rooks River granite (ER/978.318), and a cassiterite-bearing pegmatite intruding the Mathinna Beds on Clarke Island (ER/985.134). Both occurrences have been prospected with some ore being assayed from Clarke Island (Blake 1947). The genetic association for the single, Clarke Island, feldspar-white-mica-

quartz pegmatite (43932) is not known. No modern prospecting has been attempted to test the extent of the pegmatite. The Rooks River aplites have low economic potential, but may be the source rock type for cassiterite in the nearby sediments. Molybdenite crystals (43866) up to 1 cm in diameter were also found in quartz veins south of Double Peak (ER984.286). Blake (1947) noted 'aplitic granite' as carrying cassiterite at Mt Kerford and on his map indicates a 'tin lode' in Kent Bay. The site of the 'tin lode' is a garnet-bearing pegmatite (43294). Blake (1947) also records minor gold and graphite occurrences in the Mathinna Beds on the north coast of Cape Barren Island.

The main mineralization on Cape Barren Island consists of secondary cassiterite deposits. To define areas with the greatest potential for secondary cassiterite deposits, possible source rocks for cassiterite have been identified. Two plutons, the Rooks River granite and the Hogans Hill granite, have characteristics similar to granites which carry primary cassiterite and are closely associated with secondary deposits in Tasmania. Sedimentary sequences resting on and near both plutons have been prospected, and cassiterite has been produced from the Rooks River area. This regional mapping approach to cassiterite prospecting has greatly reduced the area of primary targets in the sedimentary sequences around the island. Further exploration should be concentrated on streams which drain these two altered plutons. Using this guideline the sediments in the Modder River tin field do not warrant further exploration. The source of the cassiterite in this area may be the Rooks River granite, the cassiterite possibly being shed from this mass when the topographic configuration was different from the present, as only a small area of the granite is drained by the present river system. Also cassiterite-bearing dykes or quartz veins from the Rooks River granite may outcrop in the upper watershed of the Modder River. The high ilmenite content in these and other sediments in the Cape Barren Island area is probably derived from the dolerite dykes which intrude most rock types.

Detailed mapping of rock types within the Rooks River granite may be used to further restrict the areas of potential cassiterite-bearing sediments. Based on the similarities between the cassiterite-bearing aplites and the granite porphyries, and the location of the Rooks River tin field in an area which drains mainly porphyry rock types, the southern end of the Lee River drainage system possibly has the greatest potential for cassiterite-bearing sediments. Further weight is given to this proposal by the high white-mica content of the granite porphyry in this area. The increased degree of alteration in this area is also emphasized by the occurrence of alluvial topaz along Topaz Ridge, to the north of Battery Bay Hill (fig. 3).

Extensive drilling in the Rooks River tin field (Appleby and McEwan 1966; Standard 1972) revealed variable and low cassiterite contents in the Tertiary sediments. The higher concentrations in the upper (mainly Quaternary) sedimentary sequence, which has been mined, may be related to recent alluvial and aeolian reworking of the older coastal sediments. A similar cassiterite distribution may occur in the Lee River valley. The sediments north and south of Hogans Hill have the form of alluvial fans, and a marine sedimentary component is not expected in this area.

SUMMARY

The geological history of the southern Furneaux Group is similar to that of the northeastern Tasmanian mainland. The Siluro-Devonian Mathinna Beds, following low-grade regional metamorphism and folding, were intruded by at least sixteen granitoid rock plutons. The granitoids were intruded in turn by a swarm of tholeiitic dolerite dykes, probably pre-Permian in age. There is no geological record after the dolerite dykes in the Furneaux Group until the Tertiary when thick sediment sequences were deposited in different sedimentary environments. The main Quaternary features in this area are parabolic dunes and lunettes, and modern parallel dunes and blowouts on the present coastline.

The granitoid plutons in the southern Furneaux Group are characterized by the occurrence of aluminous mafic phases. In four plutons garnets or cordierite are a widespread accessory or minor phase. In four other plutons garnet and corierite are rare accessory minerals. These eight plutons constitute some 70 per cent of the exposed granitoid rock outcrop. Secondary cassiterite deposits are concentrated in sediment sequences derived from two of four altered, biotite-bearing plutons. Both altered plutons are younger than the surrounding granitoids. Three small hornblende-biotite granodiorite plutons occur in the western area of the southern Furneaux Group.

ACKNOWLEDGEMENTS

I wish to express my appreciation to BMI Mining Proprietary Limited for logistical support in the field during the mapping of Cape Barren Island. Mr. D.J. Jennings contributed to the field work in the Hogans Hill area and encouraged me in all aspects of the work. Mr. D.J. Jennings and Dr. M.R. Banks kindly reviewed preliminary versions of this manuscript.

REFERENCES

Appleby, W.R. and McEwan, I.R., 1966: Progress report on the exploration for alluvial tin deposits in N.E. Tasmania and the Furneaux Group. *Utah Development Company, Report No.* 139.

Banks, M.R., 1962: Silurian and Devonian Systems, *in* THE GEOLOGY OF TASMANIA, *J. geol. Soc. Aust.* 9: 177-187.

Blake, F., 1947: The Furneaux Group of Islands . *Unpub. Rep. Dep. Mines Tasm.*, 1947: 52-82.

Cocker, J.D., 1977a: Petrogenesis of the Tasmanian granitoids. Thesis, University of Tasmania, (*Unpublished*).

_____, 1977b: The geology of the St. Helens area: granitoid rock petrology and structure, *in* The Blue Tier Batholith, by Groves, D.I., Cocker, J.D., and Jennings, D.J. *Bull. geol. Surv. Tasm.*, 55.

_____, in prep.: Petrogenesis of Devonian garnet and cordierite granites in northeastern Tasmania.

Coscombe, P.W., 1965: Report on a geological reconnaissance of Cape Barren Island with proposals for drilling stanniferous leads. *Utah Development Company, Report No.* 133.

Crespin, I., 1945: Middle Miocene limestone from Cape Barren Island, Furneaux Group, Bass Strait. *Pap. Proc. R. Soc. Tasm.*, (1944): 13-14.

Groves, D.I., 1972: The zoned mineral deposits of the Scamander-St.Helens district. *Bull. geol. Surv. Tasm.*, 53.

_____, 1973: Notes on the reconnaissance of the granite rocks of Flinders Island. *Tech. Rep. Dep. Mines Tasm.*, 15: 9-11.

_____, 1977: The geology, geochemistry and mineralization of the Blue Tier Batholith *in* The Blue Tier Batholith, by Groves, D.I., Cocker, J.D., and Jennings D.J. *Bull geol. Surv. Tasm.* 55.

Harris, W.K., 1965: Report on microflora in northeastern Tasmania and the Furneaux Group, *in* Report on a geological reconnaissance of Cape Barren Island with proposals for drilling stanniferous leads, by Coscombe, P.W. *Utah Development Company, Report No.* 133.

Hope, J., Brown, G. and McIntosh, B.S., 1974: Natural history of the Hogan Group. 1. Physical environment and vertebrate fauna. *Pap. Proc. R. Soc. Tasm.*, 107: 65-72.

Jennings, D.J. 1977: The geology of the Mt William area, *in* The Blue Tier Batholith, by Groves, D.I., Cocker, J.D. and Jennings, D.J. *Bull. geol. Surv. Tasm.* 55.

Jennings, D.J., and Sutherland, F.L., 1969: Geology of the Cape Portland area with special reference to the Mesozoic (?) appinitic rocks. *Tech. Rep. Dep. Mines Tasm.*, 13: 45-82.

Johnston, R.M. 1879: Notes on certain Tertiary and post-Tertiary deposits. On Flinders, Barren, Badger and other Islands in Bass Strait. *Pap. Proc. R. Soc. Tasm.* (1878): 41-50.

Keid, H.G.W., 1949: Mineral deposits on Flinders and Cape Barren Islands. *Unpub. Rep. Dep. Mines Tasm.*, 1949: 30-48.

McNeil, R.D. 1965: The geology of the Mt Elephant-Piccaninny Point area, Tasmania. *Pap. Proc. R. Soc. Tasm.*, 99: 24-59.

Moore, J.G. and Lockwood, J.P., 1973: Origin of comb layering and orbicular structure, Sierra Nevada Batholith, California. *Geol. Soc. Am. Bull.*, 84: 1-20.

Quilty, P.G., 1971: The biostratigraphy of the Tasmanian marine Tertiary. *Pap. Proc. R. Soc. Tasm.*, 106: 25-44.

Standard, J.C., 1972: Results of exploration programme, Cape Barren Island EL 18/70. *B.M.I. Mining Pty. Ltd.*

Streckeisen, A., 1975: To each plutonic rock its proper name. *Earth Sci. Rev.*, 12: 1-33.

Sutherland, F.L., 1973: The geological development of the southern shores and islands of Bass Strait. *Proc. R. Soc. Vict.*, 85: 111-144.

_____, and Kershaw, R.C., 1971: The Cainozoic geology of Flinders Island Bass Strait. *Pap. Proc. R. Soc. Tasm.*, 105: 151-176.

Williams, E., 1959: The sedimentary structures of the Upper Scamander sequence and their significance. *Pap. Proc. R. Soc. Tasm.*, 93: 29-32.

Papers and Proceedings of the Royal Society of Tasmania, Volume 114, 1980.

(ms. received 5.2.1979)

GEOLOGY OF THE BLUFF HILL POINT REGION

by P.G. Lennox
Geological Survey of Tasmania; formerly Geology Department, University of Tasmania

(with five text figures and one plate)

ABSTRACT

LENNOX, P.G., 1980 (31 v): Geology of the Bluff Hill Point region. *Pap. Proc. R. Soc. Tasm.*, 114: 69-79 (inc. one plate). ISSN 0080-4703. Geological Survey of Tasmania, Department of Mines, Hobart, Tasmania, Australia.

The cross-bedded and ripple-marked, supermature quartz-arenite sequence outcropping at Bluff Hill Point encloses a 125 metre + thick dominantly mudstone sequence. Sedimentary features include graded bedding, scour and fill structures, pseudonodules, clastic dykes and load cast structures of various morphologies. This sequence, which is of a very low metamorphic grade, displays two phases of folding, each phase associated with cleavage. The earlier phase consists of folds with hingelines trending north-westerly. The later fold phase has hingelines trending north to north-north easterly.

Similarities with the Rocky Cape Group exposed between Port Latta and Jacobs Boat Harbour have been noted, although there are differences in cross-bedding patterns and relationships between the fold phases.

INTRODUCTION

Geological reconnaissance of the Bluff Hill Point - Trowutta area (Longman and Matthews 1962) resulted in the subdivision of the Late Proterozoic rocks into a sequence of interbedded quartzite, shale, sub-greywacke and rare conglomerate (north of the Arthur River) and an underlying sequence of interbedded green chloritic shale and quartzite (south of the Arthur River). This Late Proterozoic, sequence of very low metamorphic grade is considered to be a correlate of the Rocky Cape Group which crops out between Port Latta and Jacobs Boat Harbour (Williams and Turner 1974; Gee 1967, 1968, 1971).

The purpose of this paper is to describe the sedimentology and structural geology of the Bluff Hill Point region, to compare this region with coastal exposures from Green Point to Temma and to test the validity of past regional correlations.

The area is accessible during summer along sand tracks off the road from Marrawah to the Arthur River (see figure 1).

SEDIMENTOLOGY AND STRATIGRAPHY

The sequence between Church Rock and Bluff Hill Point consists of cross-bedded quartz-arenite beds. Cross-bedding is generally of planar type although some trough cross-bedding is present. The tops of beds are often ripple-marked. The quartz-arenite sequence conformably overlies a mudstone sequence in excess of 125 metres thick, exposed between the Point designated A [BQ995573] and G [BQ998576] (see figure 2).

Rocks typical of the quartz-arenite sequence crop out at Church Rock and locality G and are well-bedded, well-sorted, white, quartz-arenite which display a sugary lustre on fresh broken faces. Typical examples are specimens 77/294H, I which are well cemented, indurated and contain up to 3% of opaque minerals. Slides referred to

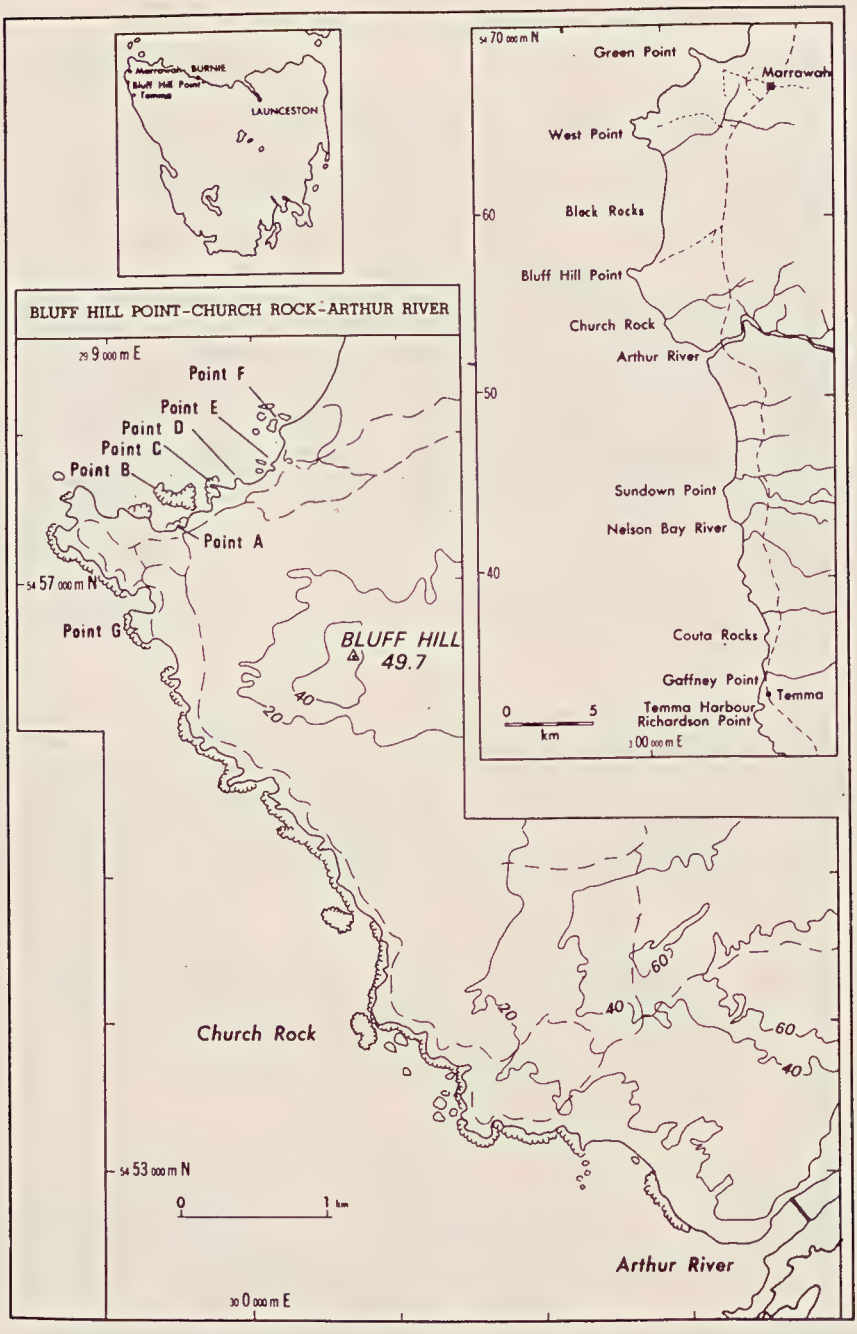


FIG. 1.- Locality map illustrating position of subject area within Tasmania, Marrawah to Temma coastal features and Bluff Hill Point to Arthur River.

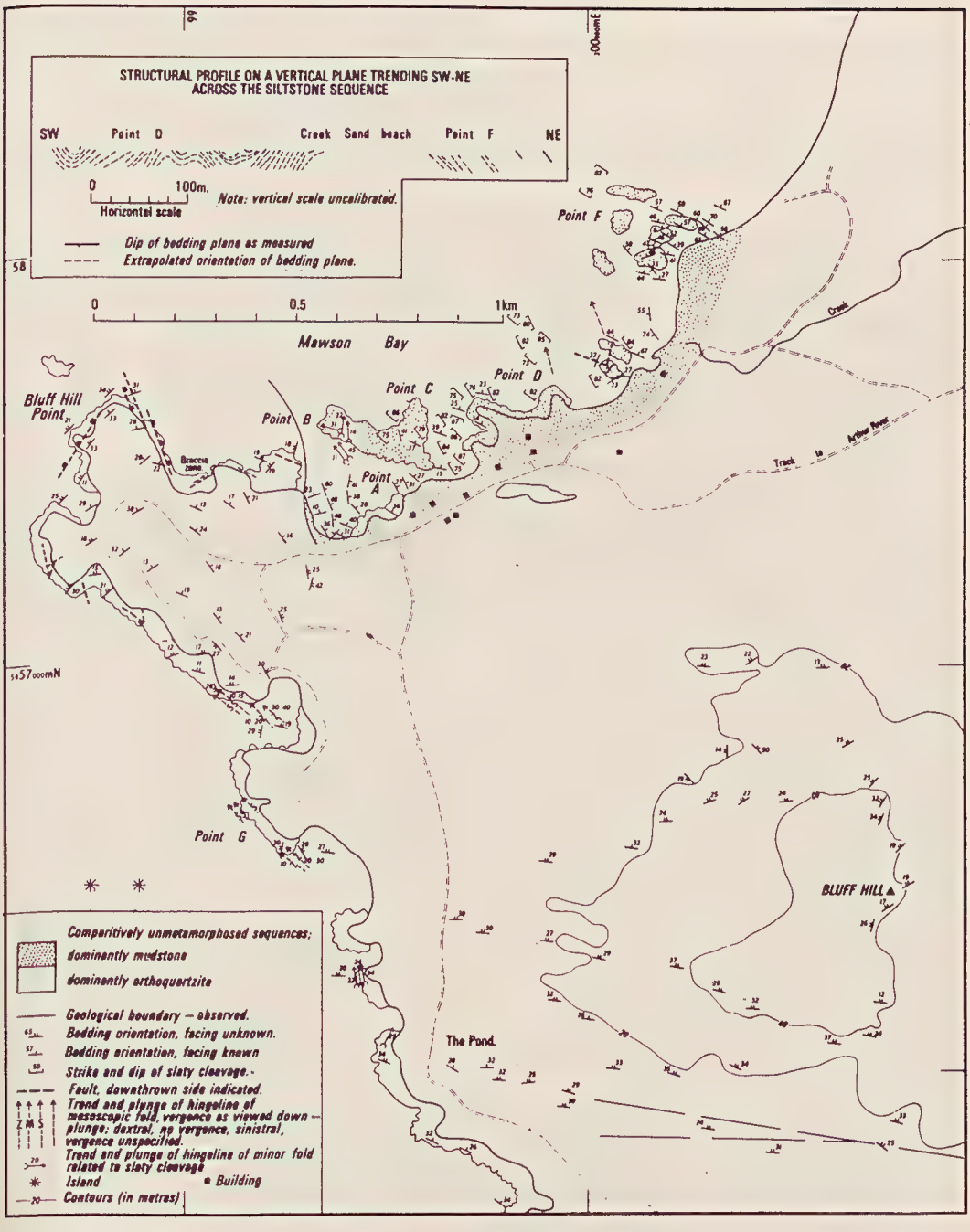


FIG. 2.- Geology at Bluff Hill Point.

in the text with a number of the form 77/2941 are retained in the Mines Department collection whilst those with a number of the form 49529 are retained in the collection of the University of Tasmania. In specimen 77/2941 discrete acicular sericite grains are usually aligned parallel to the quartz grain boundaries but occasionally the sericite grains form matted fibrous inter-growths between and within quartz grains. Sericite is less common in specimen 77/394H where it occurs as clustered fibrous sericite up to 0.08 mm long in beards at opposite ends of quartz grains. Overgrowths of quartz are formed in the Church Rock specimen and are marked by the dusty nature of quartz grain margins.

A fine-grained dolomitic-mudstone with embayed dolomite sparite clasts (up to 4 mm diameter) and zoned chert clasts indicates a paragnetic sequence as follows:- carbonate predominantly dolomite, silification and a second phase of dolomitisation. A part of this paragenetic sequence is displayed in a fault-breccia occurring at locality D [BQ997574] where chert bodies in a vein network of chert are replaced in part by dolomite grains approaching 0.5 mm in diameter.

Sedimentary features include graded bedding, scour and fill structures, pseudonodules, clastic dykes, lenticular beds with cross-lamination, load cast structures of various morphologies and possible slump structures.

Scour and fill structures with continuous bedding laminations within the fill, crop out on the point designated A [BQ995573] on figure 2 whilst at B [BQ996575] straight to gently curved channels up to 50 mm and 0.5 m long show multiple scouring and truncated fill laminae (see plate 1, fig. 1). Pseudonodules vary from non-laminated bulbous forms (one to three centimetres across) shown in plate 1 (figure 2) from locality A to laminated, cuspate bodies as exposed at B in plate 1 (figure 3). Clastic dykes occur abundantly in certain horizons throughout the succession. They are predominantly planar in form and may be aligned in the cleavage direction. Extensive polygonal clastic dyke development exposed on a bedding surface at locality D indicates a mudcrack-origin.

The isolated, semi-elliptical, double-hinged feature with micro-folded inner bedding laminations and scoured upper surface at B (plate 1, figure 4) may have formed by loading during and after sedimentary dewatering or by slumping of a cross-bedded sequence (Hendry and Stauffer 1975). Slumping involving movement of a dense, sediment-laden flow over the surface of the cross-bedded layers seems unlikely because of the double hinged form and scoured upper contact. The sedimentary structure in plate 1 figure 5 outcrops in a 0.5 m thick bed consisting of internally deformed tight to isoclinal, recumbent folds with hingelines of variable orientation and is considered to have been formed by sedimentary dewatering.

A combination of loading by the 10-20 mm thick bedded denser silty upper layers and sedimentary dewatering and erosion probably resulted in the structures illustrated in plate 1, figures 6 and 7.

The recumbent, tight to isoclinal fold with bevelled lower surface and unscoured upper surface on the coast between localities D and C may be of a slump origin (see plate 1, figure 8).

Longman and Matthews (1962) divided the comparatively unmetamorphosed Precambrian on the West Coast from Marrawah to Temma into a number of formations. Their assignment of the Bluff Hill Point sequence to the interbedded quartzite, sub-greywacke and rare conglomerate beneath the Byrant Hill Quartzite is accepted.

A total of 100 measurements of cross-bedding direction were made at three stations -

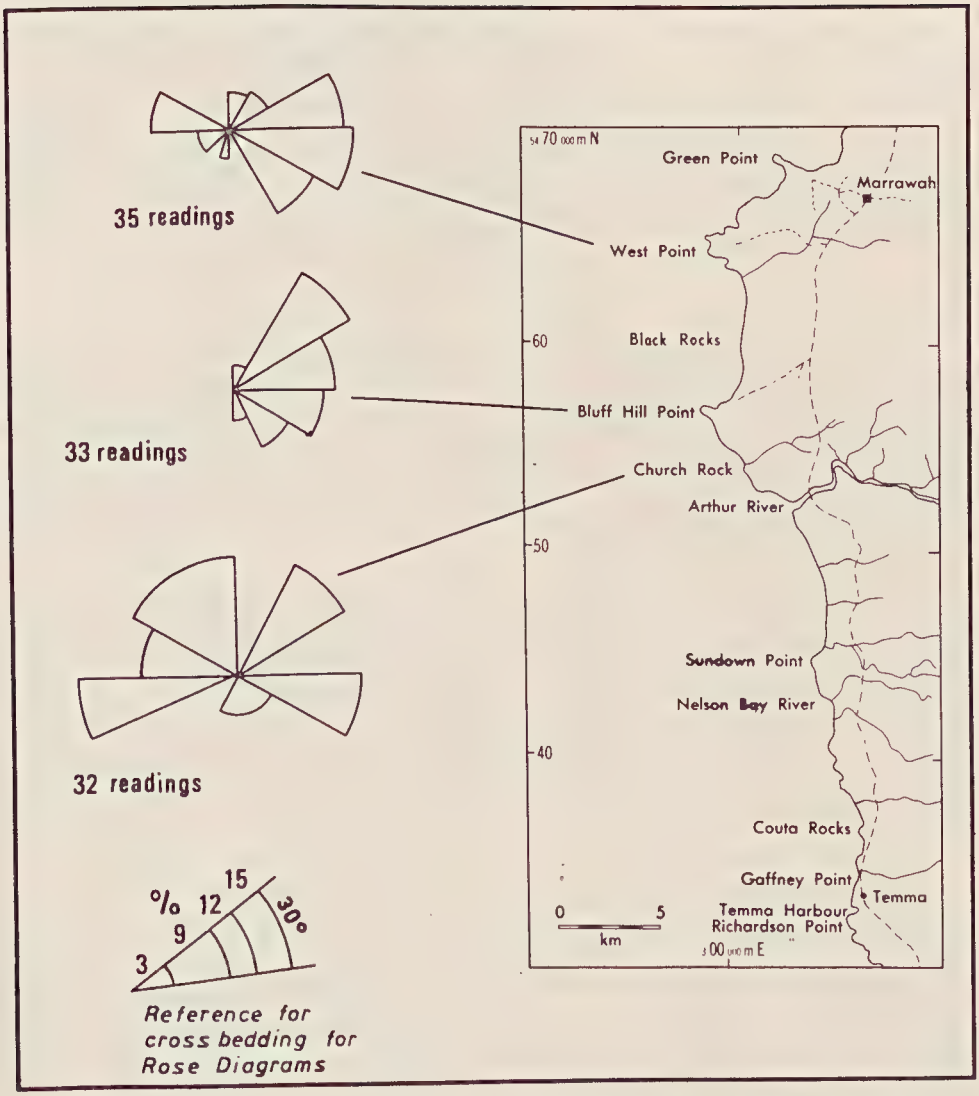


FIG. 3.- Cross-bedding directions in the quartz-arenites of West Point, Bluff Hill Point proper and Church Rock.

Church Rock, Bluff Hill Point and West Point, representing 10 km of coastline between Marrawah and the Arthur River. The structure in the Bluff Hill Point and West Point area is geometrically simple. At Bluff Hill Point the quartz-arenite sequence is folded into an open, upright, gently-plunging anticline (half-wavelength about 600 metres). The hingeline plunges 22° to 030° and the axial surface is sub-parallel to the second cleavage. The upright anticline on West Point plunges 30° to 228°. The axial surface is almost parallel to the first cleavage which is dominant in this area. The folds of the two phases of deformation affecting the Marrawah - Temma region are not co-axial (see structural geology section). Thus tilt-correction methods for unrolling sedimentary lineations on plunging, cylindroidal, flexural folds do not yield the original current directions. However, tilt-corrected aximuths yield patterns which may be compared with similarly corrected azimuths determined in other regions. Tilt-corrected azimuths for each station are grouped in 30 degree sectors and are displayed as rose diagrams as shown in figure 3. These rose diagrams do not reveal a single, consistent, well-developed mode in contrast to Gee's (1971) diagrams for the orthoquartzites of the Rocky Cape Group between Rocky Cape and Jacobs Boat Harbour.

STRUCTURAL GEOLOGY

Bluff Hill Point

Within the siltstone sequence the hingelines of the smaller folds with half-wavelengths less than two metres are contained within the surface of the primary cleavage (dips 78° to 226°) which is dominant, (figures 2, 4c and 4d). The axial surface of the large open, gently-plunging anticline (half-wavelength about 600 metres) on Bluff Hill Point is orientated subparallel to the secondary crenulation cleavage observed within the sequence (dips 76° to 312°). The axial surface of the up to three metre half-wavelength, asymmetric to monoclinal, gently-plunging, open upright folds observed on the foreshore within the vicinity of point G [BQ992566] are also subparallel to the dominant cleavage orientation.

The stereoplot of poles to bedding for the siltstone sequence shown in figure 4a may indicate two possible pi-pole girdles although the spread of poles is too narrow to determine the girdle orientation. All stereoplots are lower hemisphere and are equal area projections. The pi-pole girdle formed from poles to bedding readings usually reflects the local regional fold hingeline within an area. One possible pi-pole girdle envisaged from the stereoplot of poles to bedding for the siltstone sequence has a hingeline within the surface of the dominant cleavage observed at Bluff Hill point (dips 78° to 226°). The stereoplot of poles to bedding orientation for the orthoquartzite sequence may also possibly reflect two pi-pole girdles although the range of poles is too small to permit the girdle orientation to be determined (see figure 4b).

Slides 4529, 45921 show that the poorly developed cleavage dipping 76° to 312° crenulates the dominant cleavage (78° to 226°) observed at Bluff Hill Point. In outcrops an anastomosing cleavage develops near localities C and F, reflecting the interaction of the two cleavages. In thin section the dominant cleavage is a lepidoblastic sericite fabric in the mudstone. This fabric is transected by narrow crenulate zones at a high angle with a minority of discrete sericite grains in the matrix aligned parallel to the crenulate zones. A quartz-wacke from Island Point (45918) shows bent detrital muscovite grains. One specimen of orthoquartzite (45930 from the cliffs 0.5 km west of the Marrawah - Arthur River road on the Bluff Hill Point Track shown distinct incipient dissolution stringers.

Marrawah to Temma

The two cleavages observed at Bluff Hill Point occur throughout the Marrawah to Temma coastal platform exposures briefly examined by the author (figure 5).

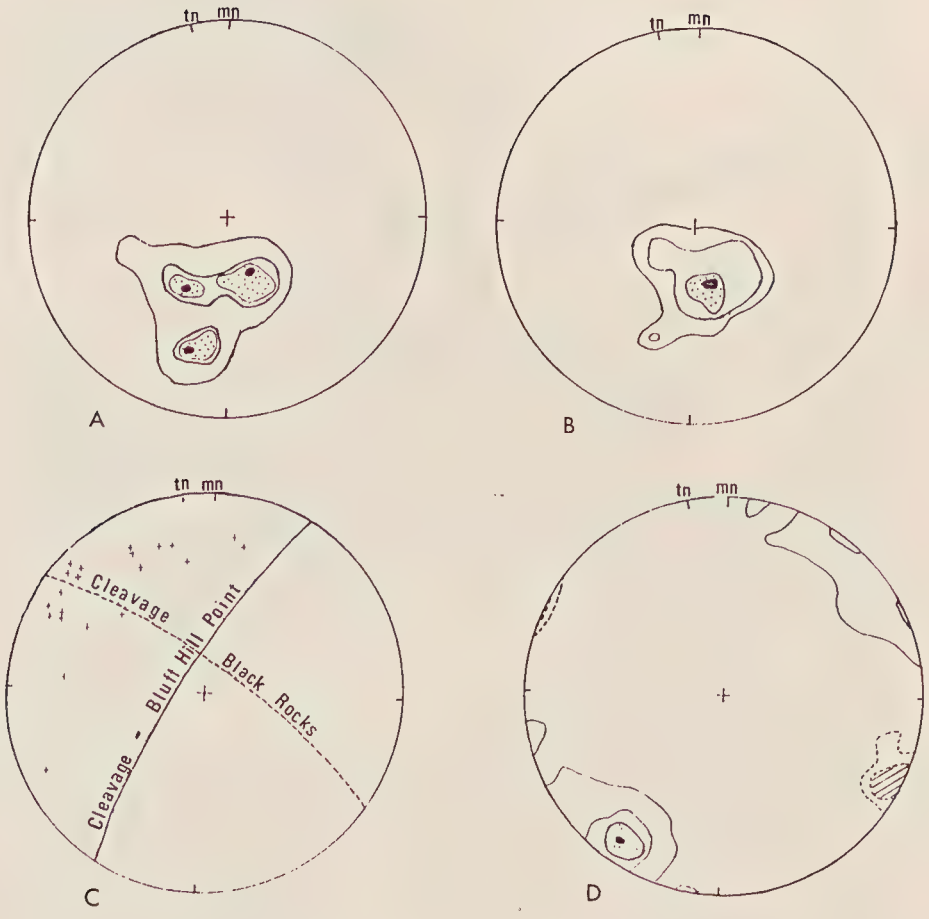


FIG. 4.- Bluff Hill Point - contoured equal area projections on the lower hemisphere:-
(a) Siltstone sequence - poles to bedding 220 readings, 2-4-6-8-10-14% per 1% area.
(b) Quartz-arenite sequence - poles to bedding 321 readings 2-4-6-8-10-16-20% per 1% area.
(c) Minor fold hingelines 24 readings. Solid line is the great circle for averaged value of second cleavage, dashed line of first.
(d) Bluff Hill Point - poles to cleavage 65 readings 2-6-10-20-30% per 1% area.
North Black Rocks - poles to cleavage 6 readings 16-32; per 1% area.

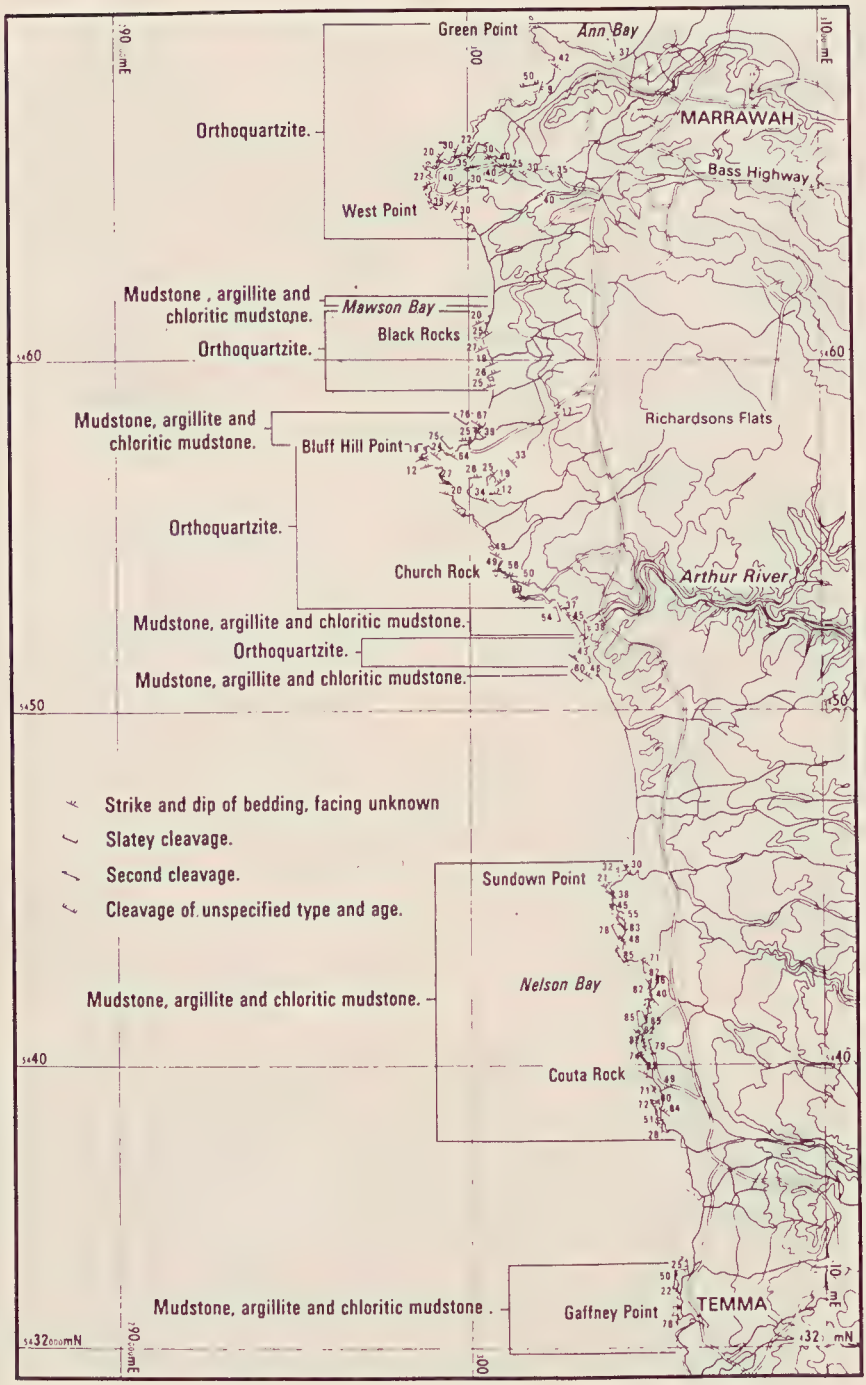


FIG. 5.- Marrawah to Temma - coastal geology

The West Point quartz-arenite sequence is folded into a large, open, upright, gently-plunging anticline of 2 km half-wavelength with a hingeline which plunges 30° to 328° within the dominant primary cleavage surface observed at Bluff Hill Point.

The dark grey argillite exposed on the headlands adjacent to the Arthur River display in thin section a lepidoblastic sericite fabric at a low angle to bedding. The first cleavage bends detrital micas and is transerected by rare metamorphic white micas and discrete opaque stringers up to 0.4 mm long at a high angle to bedding defining the second cleavage (77/839). The measured orientation of these two cleavages on the Arthur River headlands is similar to those observed at Bluff Hill Point.

There is a progressive change in the strike of the country rock from Bluff Hill Point (NW - SE) to Temma (N - S) together with a gradual steepening of the dip of the beds from north to south.

SUMMARY AND CONCLUSIONS

The Lower Palaeozoic Rocky Cape Geanticline (Williams 1978) which occupied the whole of the north-west of Tasmania contains the very low metamorphic grade Rocky Cape Group between Port Latta and Jacobs Boat Harbour. The Rocky Cape Group (Gee 1971) consists of two formations of super-mature quartz-arenite, each more than 1200 m thick, and formations of cleaved siltstone. The Marrawah to Temma coastal outcrops consists of super-mature quartz-arenite, chloritic-mudstone and argillite which can probably be correlated with the Rocky Cape Group (Gee *ibid;* and Williams and Turner 1974).

Insufficient stratigraphic analyses have been completed along the entire Marrawah to Temma coastal exposures to permit a full comparison of this sequence with the Rocky Cape Group. The lithology, sedimentary features and low metamorphic state of the sequence at Bluff Hill Point are similar to parts of the Rocky Cape Group exposed between Port Latta and Jacobs Boat Harbour (Gee *ibid*). However, the pattern of the tilt-corrected cross-bedding with the West Coast quartz-arenite sequence does not display a single, consistent mode like those Gee (*ibid.*) calculated from the quartz-arenite sequence within the Rocky Cape Group between Rocky Cape and Jacobs Boat Harbour.

Structural analysis shows that the West Coast sequence exhibits two phases of folding which both result in the development of gently-plunging-open, upright, minor (half-wavelength 2-3 metres) to major (half-wavelength = 2 km) folds. The first phase of folding resulted in the development of north-westerly plunging, symmetrical folds of 2 km half-wavelength and asymmetric to monoclinal, gently north-westerly plunging minor folds. The lepidoblastic sericite fabric defining the first cleavage is aligned within the axial surface of these folds. Northerly to north-north-easterly plunging folds of similar style to the first phase folds mark the second phase of folding. A cleavage which crenulates the lepidoblastic sericite fabric lies within the axial surface of the second phase folds. In comparison the Rocky Cape Group exhibits east of Rocky Cape, one phase of folding, which produced a slaty cleavage and high-angle thrusts. The plunge of these folds was increased to the north by rotation about a hinge at right angles to the axial surface. A later sub-horizontal strain-slip cleavage was developed in some localities.

ACKNOWLEDGEMENTS

This paper formed a large part of an Honours Thesis submitted to the Geology Department, University of Tasmania in 1976, a thesis supervised by Dr. C.A. Boulter. Many useful discussions have been held with P. Williams and Dr. E. Williams. My thanks for their constructive criticism of the manuscript. This paper is published with the permission of the Department of Mines.

REFERENCES

Gee, R.D., 1967: The tectonic evolution of the Rocky Cape Geanticline in North-West Tasmania, *Unpublished Ph.D. Thesis*, University of Tasmania, 351pp.

_____, 1968: A revised stratigraphy for the Precambrian of north-west Tasmania, *Pap. Proc. R. Soc. Tasm.*, 102: 7-10.

_____, 1971: Geological atlas 1 mile series Zone 7 Sheet 22 (8016S) Table Cape, *Explan. Rep. geol. Surv. Tasm.*

Hendry, H.E. and Stauffer, M.R., 1975: Penecontemporaneous recumbent folds in trough cross-bedding of Pleistocene sands in Saskatchewan, Canada. *J. Sedim. Petrol.*, 45(4): 932-943.

Longman, M.J. and Matthews, W.L., 1962: The geology of the Bluff Point and Trowutta Quadrangles. *Tas. Dept. Mines Technical Report* 6: 48-54 and 79-85.

Williams, E., 1978: Tasman Fold Belt System in Tasmania, *Tectonophysics*, 48: 159-205.

_____, and Turner, N.J., 1974: Geological Atlas 1:250,000 Series Sheet No. SK-55/3. Burnie, *Explan. Rep. geol. Surv. Tasm.*

PLATE 1

Figure 1 : Bluff Hill Point - Point B - scour and fill structure (lens cap is 5 mm thick).

Figure 2 : Bluff Hill Point - Point A - pseudonodules (divisions are 100 mm wide).

Figure 3 : Bluff Hill Point - Point B - pseudonodules (lens cap is 5 mm thick).

Figure 4 : Bluff Hill Point - Point B - sedimentary dewatering structure (?), (geology pick handle is 40 mm thick at its base).

Figure 5 : Bluff Hill Point - Point A - sedimentary dewatering structure (?), (divisions are 10 mm wide).

Figure 6 : Bluff Hill Point - Point A - sedimentary dewatering structure (?), (divisions are 10 mm wide).

Figure 7 : Bluff Hill Point - Point B - sedimentary dewatering structures in well - laminated siltstone (geology pick is 300 mm long).

Figure 8 : Bluff Hill Point - Point C to D - possible slump structure, (geology pick head is 20 mm thick).

PLATE 1

Papers and Proceedings of the Royal Society of Tasmania, Volume 114, 1980.

(ms. received 24.4.1979)

EROSION AND RABBITS ON MACQUARIE ISLAND: SOME COMMENTS

by B.J. Griffin
Geology Department, University of Tasmania

(with one plate)

ABSTRACT

GRIFFIN, B.J., 1980 (31 v): Erosion and rabbits on Macquarie Island: some comments. *Pap. Proc. R. Soc. Tasm.*, 114: 81-83 (incl. one plate). ISSN 0080-4703. Department of Geology, University of Tasmania, Hobart, Tasmania, Australia.

Rapid emergence and subsequent glacial and periglacial action on Macquarie Island have placed it in a state of high erosional activity. The dominant processes are mass erosion through landslips, soil creep slumping and solifluction. Fluvial and aeolian erosion are only important in very restricted areas. Rabbit activity has had a minimal effect on the overall rates of erosion although appearing significant in some localised areas.

INTRODUCTION

Macquarie Island is widely recognised as an extremely interesting area in terms of most natural sciences. This brief report looks at erosion processes on the island and the effects of the rabbit population on these processes and their rates of operation. the 34 km by 3 km island lies almost midway between the Australian mainland and the Antarctic continent, and is a subaerial exposure of the Macquarie Ridge. Physically it is dominated by a 200-300 m high plateau bounded by very steep slopes and cliffs with only very minor low-lying coastal terraces. These raised marine terraces are of middle to late Holocene age, indicating an average uplift rate of the island between 1.5 and 4.5 m per 1000 years (Colhoun and Goede 1973).

Geologically Macquarie Island is at present considered to represent Miocene oceanic crust generated in a spreading ridge environment (Varne and Rubenach 1972). The northern tip and southern three-quarters of the island are composed of basaltic pillow lavas and associated dolerite dykes. The remaining northern quarter is composed of more massive units of coarser-grained gabbros and ultramafic rocks.

The Colhoun and Goede (1974) have shown that former ice action on the island was dominated by local plateau, valley and cirque glaciers which covered, at their maximum extent, some 40% of the island, rather than by complete over-riding of an easterly moving ice sheet (Mawson 1943). Present landforms are dominantly of former periglacial and glacial origin. The current climatic conditions are humid periglacial.

PREVIOUS STUDIES OF EROSION

Few observations have been made of erosion processes on Macquarie Island. However various workers in other disciplines have made some brief comments. Taylor (1935) suggested that rabbit grazing is having catastrophic effects, in terms of erosion, on the grassland areas of Macquarie Island. This view was strongly supported by Costin and Moore (1960). They suggested that on the steeper slopes, which include grassland slopes in excess of 70° up to an altitude of 300 m, elimination of the stabilizing dominants, *Poa foliosa* and *Stilbocarpa polaris*, by rabbit grazing will almost certainly increase the incidence of minor landslips, resulting in the stripping of blanket bog peats and the development of screes. They finally suggested that small landslips in otherwise intact slopes often initiate an irreversible trend towards soil loss.

CURRENT OBSERVATIONS AND DISCUSSION

Soil creep is the major erosion mechanism on Macquarie Island. This is a continuous process with material gradually moving downslope under gravity. On Macquarie Island the soil-rock interface is permanently saturated; a result of the continuous heavy drizzle and low mist that characterise the weather conditions on the island. Precipitation is rarely heavy and many of the water channels on the island today are relict meltwater channels which are generally underfit (Colhoun and Goede 1974). Consequently today fluvial erosion does not play a major role on Macquarie Island.

The most spectacular form of mass movement, namely landslips, are very common on Macquarie Island. This is not surprising because the mass movement mantle is in a permanent state of instability and only requires a suitable trigger to move more rapidly as a landslip. During the three months 1975/76 summer field season it was observed that a number of landslips occurred immediately after the heaviest rainfall period of the summer. This correlation of landslips occurring after heavy rain periods has also been observed subsequently (G. Copson, *pers. comm.*). Another recognised trigger is large earthquakes and as Macquarie Island is seismically very active, earthquakes as well as heavy rain periods form the major triggers for the landslip activity. The irreversible soil loss trend after landslips suggested by Costin and Moore (1960) has not been observed by the author. On most of the slopes on both coasts it is possible to see landslip areas in various stages of revegetation (plate 1a). Bare rock is only exposed, if at all, at the head of the slip and this is quickly covered by collapse of upslope material.

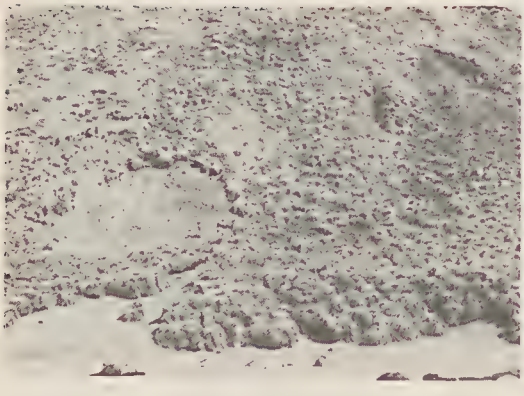


PLATE 1a. - Recent and revegetated landslips on steep coastal tussock slopes near Nuggets Point at the northern end of Macquarie Island.

PLATE 1b.- Terracettes on a grassed hillslope.

Many of the grassland slopes contain small terraces or terracettes (plate 1b). These are commonly misnamed "sheep tracks" throughout rural mainland Australia and on Macquarie Island some workers have similarly misinterpreted these features as due to rabbit tracks or squats. Actually these features are usually a result of creep processes, solifluction and or occasionally small scale slumping.

Wind is another erosive agent on Macquarie Island; during the three month 1975/6 summer the average wind speed was 26 km per hour. However because of the moist surface environment wind deflation effects are drastically reduced relative to those in drier environments. Moist clay has strong interparticle adhesion so that only during the rare dry periods if ever, are the clays deflated. Coarser material is more susceptible and fossil aeolian dunes deposited along the natural wind 'funnel' between Sandy Bay on the east coast and Bauer Bay on the west coast are being eroded through wind deflation. Observations suggest that this was initiated by rabbits burrowing on the windward side of the dunes. Erosion of raised marine ridges on the coastal terraces is probably also a result of similar rabbit activity. These areas are very small relative to the whole island and insignificant in terms of the overall erosion processes.

It has also been suggested that rabbits have increased the incidence of landslips by weakening an area through burrowing. No evidence has been presented on this and a visual comparison of the island today with photographs taken at about the time of introduction of rabbits would suggest that the rate of occurrence has not significantly altered. Furthermore areas of burrowing petrel colonies, which have a higher burrow density than rabbits, are not obviously more eroded than adjacent areas.

In summary, the major processes active on Macquarie Island are various forms of mass movement. Although rabbits may have severe botanical effects on the ecology, they have had little effect on the erosion of Macquarie Island. It is invalid to compare Macquarie Island with mainland Australia because of the major climatic differences and such comparisons are misleading.

ACKNOWLEDGEMENTS

Many people have provided fruitful discussion and advice on this topic, in particular Mr. G. Copson, Dr. E. Colhoun and Dr. J. Jenkins. Mr. G. Copson is thanked for supplying the photographs. The National Parks and Wildlife Service of Tasmania, the Australian Antarctic Division and the University of Tasmania have provided logistic support and funding for two visits to the island and this is gratefully acknowledged.

REFERENCES

Colhoun, E.A., and Goede, A., 1973: Fossil Penguin Bones, ^{14}C Dates and the raised marine terraces of Macquarie Island: some comments. *Search*, 4(11): 499-501.

_____, 1974: A reconnaissance survey of the glaciation of Macquarie Island. *Pap. Proc. R. Soc. Tasm.*, 108: 1-19.

Costin, A.B., and Moore, D.M., 1960: The effects of rabbit grazing on the grasslands of Macquarie Island. *J. Ecol.*, 48: 729-732.

Cumpston, J.S., 1968: Macquarie Island. ANARE *Scientific Reports, Series A*, 93.

Mawson, D., 1943: Macquarie Island: its geography and geology. *Australasian Antarctic expedition 1911-1914 Scientific Reports, Series A*, 5.

Taylor, B.W., 1955: The flora, vegetation and soils of Macquarie Island. *Australian National Antarctic Research Expedition Reports, Series B.*, 11.

Varne, R., and Rubenach, M.S., 1972: Geology of Macquarie Island and its relationship to oceanic crust. *Amer. Geophys. Union, Antarctic Research Series*, 19: 251.

Papers and Proceedings of the Royal Society of Tasmania, Volume 114, 1980.

(ms. received 24.10.1979)

OBSERVATIONS ON SOME TASMANIAN FISHES: PART XXVI.

by E.O.G. Scott
Launceston

(with seven tables and two text figures and two plates)

ABSTRACT

SCOTT, E.O.G., 1980 (31 v): Observations on some Tasmanian fishes: Part XXVI. *Pap. Proc. R. Soc. Tasm.*, 114: 85-144 (incl. two plates). ISSN 0080-4703. 82 Penquite Road, Launceston, Tasmania, Australia.

One new species is described one species is added to the local list and observations are presented on eight other species most of which are rarely met with in Tasmanian waters.

SCYLIORHINIDAE - *Galeus boardmani* (second Tasmanian record, general description, possible sexual dimorphism). TRIAKIDAE - *Furgaleus ventralis* (first Tasmanian record, adult female and 3 full-term embryos, morphometric data, allometric growth, key to Tasmanian Triakidae). XENOCONGRIDAE - *Muraenichthys (M.) lengomena, sp. nov.* (type 2 paratypes, described and figured). OPHICHTHYIDAE - *Ophisurus serpens* (third Tasmanian record, general description). SYNGNATHIDAE - *Histiogamphelus briggsii* (first local specimen reported since original description exhibits some features of *H.b. briggsii* and some of *H.b. orae* — suggested subspecies be abandoned). KYPHOSIDAE - *Girella tricuspidata* (xanthic individual). SOLEIDAE - *Zebrias fasciatus* (confirmatory local record). ODACIDAE - *Neoodax attenuatus* (descriptions of 3 specimens; species hitherto known from 4 examples only). URANOSCOPIDAE - *Kathetostoma giganteum* (general account of second and third reported local examples); *Gnathagnus innotabilis* (morphometric and other features of 8 specimens, 4 being Tasmanian; no published local record of species at date of completion of MS). TETRAODONTIDAE - *Boesemanichthys firmamentum* (general account of second and third local specimens).

In the case of several species one or more of three sets of dimensions has been found to be significantly collinear in a loglog plot with as abscissae natural numbers: the relation involves length of head, length to vent, standard length; lengths to insertions and terminations of certain fins; lengths of spines and rays. Polynomial equations for head in plan have been calculated for several species; in one instance parameters have been found to show significant correlation with standard length.

INTRODUCTION

This paper follows the general plan of others in the series. Linear measurements are given throughout unless otherwise specified in millimetres, the name of the unit commonly being omitted. The symbols *Ls, Lt, TLs, TLt* denote standard length, total length, thousandths (permillages) of standard length, thousandths of total length, respectively. Registration numbers denoted by Q.V.M. are those of the Queen Victoria Museum and Art Gallery, Launceston. Certain other conventions are noted in earlier contributions.

ERRATA IN PART XXV

Two unfortunate errors crept into Part XXV (1979). The paper on Chauliodidae ascribed (p.100) to R.C. Baird was written by J.E. Morrow (confusion occasioned by an incomplete photocopy). In an inexplicable blunder on the writer's part a specimen of *Diretmus argenteus* Johnston, 1863 was recorded (p.108) under Embiotocidae instead of Diretmidae, it being incorrectly stated Greenwood *et al.* 1966 subsumed the latter in

the former, the fact being that Diretmidae is listed by these authors as a valid family.

Family Scyliorhinidae

Six Australian species are listed in the Handbook (Munro 1956): to these McKay (1966) has added *Atelomycterus marmoratus* (Bennett, 1830) and *Halaelurus burgeri* (Muller & Henle, 1841) both based on Western Australian records. The four Tasmanian species (a) *Galeus boardmani* (Whitley, 1928) (b) *Halaelurus analis* (Ogilby, 1885) (c) *H. vincenti* (Zeitz, 1908) (d) *Cephaloscyllium isabella laticeps* (Duméril, 1853) have been keyed in Part XI (1963), which includes also observations on eight local specimens (one, a foetus, figured) of (d). Species (a) (c), not included in any local list and not accredited to Tasmania in the Check-List (McCulloch 1929), were first reported from this State by Olsen (1958), each being represented by a single example.

Genus *GALEUS* Rafinesque, 1810

Galeus Rafinesque, 1810, CARATT. NUOV. GEN. SP. SICIL., p.13. Type-species (by selection, Fowler 1908), *Galeus melastomus* Rafinesque, 1800.
Pristiurus Bonaparte, 1831, *Giorn. Aread.*, 52, p.187. Type-species, *Pristiurus melanostomum* Bonaparte = *Galeus melastomus* Rafinesque, 1800.
Figaro Whitley, 1928, *Rec. Aust. Mus.*, 16(4), p.238, as subgenus; given generic status 1929, *Aust. Zool.*, 5(4), p.354. Type-species, *Pristiurus (Figaro) boardmani* Whitley, 1928.

Galeus boardmani (Whitley, 1928)

Pristiurus sp. Whitley, 1926, *Mid-Pac. Mag.*, 31(6), p.578.
Pristiurus (Figaro) boardmani Whitley, 1928, *Rec. Aust. Mus.*, 16(4), p.238, p.18, fig.3. Type locality: Off Montague Island, New South Wales.
Figaro boardmani Whitley, 1929 *Aust. Zool.*, 5(4), p.354; 1934, *Mem: Qld Mus.*, 10(4), p.198; 1939, *Aust. Zool.*, 9(3), p.230; 1940, FISH AUST., 1, p.90, figs 78, 83; 1964, *Proc. Linn. Soc. N.S.W.*, 89(1), p.33.
Galeus boardmani: Fowler, 1941, *Bull. U.S. Nat. Mus.*, 100(13): Munro 1956, HANDBK AUST. FISH., 1, p.6, fig.34: Olsen, 1958, *Pap. Proc. R. Soc. Tasm.*, 92 p.156: Scott, 1962, MAR. FRESH WAT. FISH. S. AUST., p.24, unnumbered fig., p.24: Stead, 1963. SHARKS RAYS AUST., pp.22, 199, fig.6.

Remarks

Our knowledge of this interesting species is virtually confined to the information given in three notices of it by its author (Whitley 1928, 1929b, 1940) and a note in this journal by Olsen (1958) of the only Tasmanian specimen till now recorded. Apart from the length of the type (*Lt* 540), the maximum length of 'many specimens' in the *Endeavour* collections ('up to 16 inches') and a dozen dimensions of his specimen recorded by Olsen no morphometric data have hitherto been published; no information is available on dentition denticles or cephalic pores — apart from an observation by Whitley that these are fewer than in the extralimital *Pristiurus melanostomus* (Rafinesque, 1800) — possible sex differences have not been considered. An attempt is here made to fill these and some other lacunae.

The type locality of the species is incorrectly given by Stead (1962, p.22) as the Great Australian Bight, this being the provenance not of the type-specimen of 1926 but that of the 1913 *Endeavour* material subsequently noticed by Whitley (1939). In the paper (Whitley 1928, p.238) cited by McKay (1966, p.65) as the source of the genus *Figaro* the present species is referred to the genus *Pristiurus* with *Figaro* as a new subgenus (based on the presence of specialized denticles not only on the upper but also

on the lower surface of the caudal peduncle), *Figaro* being given generic status in the following year (Whitley 1929b, p.354; McCulloch, 1929, p.8, or, since Whitley prepared the Check-List for publication after McCulloch's death in 1925, effectively Whitley *in* McCulloch).

Material

A specimen, 378 in length to origin of upper caudal lobe, 488 in total length collected by Mr Shane Down on the continental shelf off Binalong Bay, east coast, 28 April 1979 (Q.V.M. Reg. No. 1979/5/40); second record for Tasmania, first by Olsen (1958), *Lt* 503, female, taken off Maria Island in 300 fm (550 m) on 2 July 1952.

Dimensions

The set of standard elasmobranch measurements formulated by Whitley (1943b, p.114) is set out in table 1, entries being given as thousandths of 'standard length', i.e., length from tip of snout to origin of anterior (here upper) caudal lobe (in this species the cephalad lapse of this lobe is extremely gradual, the precise point of origin being difficult to determine; in the specimen it is taken to be located at 378 mm, 2 in advance of lower lobe origin).

Some additional dimensions, all as *TLs*, follow. Distal border of first dorsal 48 second dorsal 53 anal 108 ventral 108 pectoral 127; vertical height of first dorsal second dorsal anal 48 50 48; width of ventral 50, inner border of pectoral 69. In caudal posterior border 75 lower border behind notch 50 notch to lowest point of fin 167; maximum width 93 width at notch 36 greatest width behind notch 66. Interpectoral at front of bases 130 at back 56.

Comparative dimensions

Olsen reported for his female specimen total length (503) and 10 other linear dimensions in mm. As his data do not include standard length as such (though length to origin of lower caudal lobe is noted), both these and the data for our female are here presented as *TLt*, together with approximate values for the male type as read off from the definitive figure (Whitley 1928, pl.18, fig. 3). Snout to anterior edge of eye 60 61 (Olsen) 66 (Whitley) to posterior edge of eye 99 95 105 to spiracle 109 107 112 (entry in Olsen reads by typographical error 'Snout tip to spiracle edge of eye') to 1st gill slit 150 130 148 to 5th gill slit 182 173 183 to base of pectoral 174 169 188 to vent 416 398 410. 'Base of 1st dorsal' (interpreted as length to fin origin) 451 567 437 of 2nd dorsal 652 652 638 lower caudal lobe 779 775 764.

It will be seen the agreement is in general very close. The one marked divergence, that of length to first dorsal origin as given by Olsen may possibly be attributable to a typographical error. A consideration of proportions relative to other relevant landmarks suggests the entry of 285 could well be an error for 225, which would give *TLt* length to fin origin a plausible 446.

Dentition

The dentition has not hitherto been described. It conforms to the general scyliorhinid type of a large moderately slender acute mesial cusp flanked on a broad base by two small subequal lateral cusps.

External to the normal large teeth the upper jaw presents a narrow mesial strip of several rows of minute tubercles (individual feature?). Normal teeth in 3-4 rows mesially mainly 2 rows laterally, elongate acute, two small subequal cusps arising from the angles of the broad base, about 20 in a row on each side, viewed from in front members of the rows either wholly or partly occluding each other or clearly alternate, some lateral teeth with two internal cusps and one external. Teeth in lower jaw similar to those in upper but somewhat less massive, medially in non-alternate rows,

with single cusp, rapidly decreasing in size at the sides where some develop 2 or 3 secondary basal cusps.

Denticles

(a) *Unspecialized.* On midflank basal plates subrectangular or lozenge-shaped, closely set but not in contact superficially, in crisscross rows, about 30 per 10 mm, each with a low backwardly and upwardly directed ridge terminating posteriorly in a free acute spine. On tail keel increasingly assumes form of a triangle, approximately equiangular free apex directed forward. On dorsum of snout, beginning shortly in advance of orbit and extending two-thirds of the way to snout tip a smooth somewhat depressed mesial band, on either side of this a subtriangular area (broad hind border strongly outer lateral border moderately convex, inner border virtually straight) with some three score irregularly circular clusters of about half a dozen denticles with obsolescent spines, many clusters with a central perforation. On tip of snout spines obsolete.

(b) *Specialized.* On upper surface of caudal peduncle the enlarged specialized denticles, characteristic of the genus *Galeus*, originate obscurely as a narrow, flush almost smooth band about halfway between second dorsal termination and level of lower caudal lobe origin, developing shortly into a ridge about 2 mm wide extending back to some two-thirds of distance between end of dorsal base and tip of caudal and comprising modally 2 rows of broad acute lanceolate blade-like processes modally about 1.8 mm in length directed outward backward and slightly upward, three score or more in each row; between the blades 3-4 irregular rows of minute mammilloid protuberances. Specialized denticles on lower surface of caudal peduncle, reported only in the present species, extend in a band of processes and protuberances similar to that on upper surface but with only about half as many blades, extending from just behind elongated pennon-like tip of anal at level of end of dorsal base to origin of lower caudal lobe, a mesial specialized region continuing beyond this as a low flat narrow pavement devoid of spines at least halfway up margin of lower caudal lobe. In the European species of *Galeus* the lower surface of the caudal peduncle, while devoid of specialized denticles, bears a narrow mesial band of naked skin.

Coloration

General colour light grey, about a score of brownish somewhat purplish saddles not reaching ventral profile mostly terminating above it by about one-third of height of side, saddles of two shades darker and lighter alternating usually rather clearly separated by subvertical arc of ground color. Saddles in order caudad: dark interorbital, light bordered behind by forwardly convex arc of ground color from near middle of gill slits, thereafter to end of first dorsal base 3 dark 3 light last dark under dorsal and extending briefly beyond it, interdorsal with 2 light 2 dark second dark beginning just anterior to and extending full length of second dorsal base, to level of notch of caudal 3 light 3 dark last 2 dark subcontinuous along dorsal profile. One conspicuous separate dark marking, subrectangular on left side pyriform on right, immediately behind adpressed pectoral in lower half of flank beneath second dark saddle behind head. Saddles in advance of first dorsal of more or less uniform color on both dorsum and flank, later ones tending to break up on side into 3-5 deeper alternating with less intense subvertical bars. Ventral surface in advance of gill slits chiefly off-white, snout a little darker than rest, an obscure forwardly pointed chevron immediately before pectoral, behind gill slits tolerably uniform pale greyish. Roof of mouth dusky. Upper surface of tongue mainly pale bluish anteriorly, tending to become whitish posteriorly, lower surface bluish except tip which is off-white.

Proximal portion of both dorsals somewhat darker than distal one-third, the areas separated by a broad dark stripe sloping down and back (angle much less acute than in figure of type). Anal dark greyish darker in middle of upper half. Upper surface

of pectoral about concolorous with lighter body saddles, lower surface paler more greyish. Upper surface of ventral dark greyish darker mesially, lower proximally whitish or dark greyish (darker than any part of dorsal surface) in distal half or more. Upper caudal lobe greyish in places close to white, with saddles as noted above, lower lobe much like anal but with relatively greater dark area, including an ovoid patch in upper half of anterior border, a long pennon from lowest point of fin to caudal notch bordered externally by pale grey, an obscure broad darkish arc crossing posterior half of portion of fin behind notch.

While the color pattern in the present specimen is of the same general character as that in the figure of the type it presents some marked differences. Some of these such as the presence of the large detached marking of the trunk and the detailed disposition of dark markings on caudal peduncle and on upper caudal lobe above vertebral column and anterior to notch may well represent merely individual variation. However, other markings in particular the interorbital bar (noted by Olsen as occurring in his female but not evident in the figure of the type, which does however exhibit some mesial darkening here) and the markings unrepresented in the figure, on ventral anal and caudal behind notch may possibly point to some variation in color pattern between the sexes.

Commenting on some *Endeavour* examples Whitley (1939, p.230) observed 'The colour-bands of the [Great Australian] Bight specimens (subspecies *socius nov.*) are fainter than those of the holotype'. No useful light is cast by the present example on the status of the proposed subspecies, which though mentioned in the Handbook (Munro 1956, p.6) as a 'paler variety' and maintained by its author as a formal subspecies in his name-list (Whitley 1964, p.33, entry No.36) appears to have received no more precise specification.

Possible sexual dimorphism

The type is a male. Subsequent to its description Whitley (1939, p.230) noted 'Many specimens referable to this species are in the "Endeavour" collections' trawled in Bass Strait in 1912 and in the Great Australian Bight in 1913, observing 'Curiously, all are males'. Later (1940, p.91) he wrote 'Whilst the trawlers have caught numbers of this shark, all the known specimens are males, suggesting a segregation of the sexes, perhaps for migrating purposes'. The Tasmanian example reported by Olsen (1958) was the first, the present specimen is the second female noted in the literature. In quoting Whitley's statement just cited and following it immediately by 'However, females have been caught off Tasmania' Stead (1963, p.22) would appear to imply more than Olsen's single record justifies.

Some possible differences in coloration between the sexes have been noted above. In the absence of detailed morphometric specifications of the male no firm conclusion can be drawn on the presence or absence of any significant variation in general body form: a comparison of available dimensions in the section on Proportions would indicate that in respect at least of the major morphological landmarks there considered there is good agreement between the sexes. However, our female exhibits some noticeable differences in fin shape and size from the holotype male as figured, the most marked departure being found in the anal. In the female the distal border of this fin is notably longer its tip reaching to about nine-tenths (*cf.* barely half) of length of second dorsal base, its length being about one and one-fifth of (subequal to) that of the anterior border and being contained about two and one-fifth (about two and four-fifths) in the interval between ventral and anal origins: with the fin normally posed the general sense of the distal border is noticeably closer to horizontal than in the male. Other, mostly minor, differences in the fins include: inferior border of caudal between lowest point and notch evenly sigmoid (depicted as biconcave), upper angle of terminal caudal lobe less rounded its hind border biconcave (evenly convex), pectoral relatively larger its

anterior border one and a half times (twice) in length to its origin.

Some aspects of form

(a) *Dorsal profile of head.* In his original account Whitley remarked, 'In Garman's key to the species of *Pristiurus* in his monograph of the Plagiostoma [1913] the new species comes closest to *P. eastmani* Jordan & Snyder [1904] but differs in having a more arched back....' however, after examination of the *Endeavour* material he reported 'the humped back is characteristic of the largest specimens'. The present example shows no sign of the marked convexity above the gill slits, the curve to this region being a virtually even sweep. Ten measurements of the height of the dorsal profile above the anteroposterior axis of the fish taken at equal intervals along the axis back to the level of the 5th gill slit are 8.0 11.5 14.1 15.7 17.3 18.8 19.5 20.0 20.4 20.6 mm. The curve is well fitted (R 0.9753) by a second-degree polynomial, significantly better (F 9.355*) by a third-degree (R 0.9764), non-significantly better by a fourth-degree (R 0.9766). In the subjoined equations H = height of curve, mm, N = serial decile number of measurement proceeding caudad:

$H = 6.20 + 2.8843\ N - 0.1420\ N^2$. Predicted heights 8.8 11.4 13.6 15.5 17.0 18.4 19.4 20.2 20.7 20.8.

$H = 5.11 + 3.8434\ N - 0.3500\ N^2 + 0.01260\ N^3$. Predicted heights 8.6 11.5 13.8 15.9 17.2 18.3 19.2 20.5 21.2.

(b) *Under surface of head.* A small figure has been provided for the type (Whitley 1940, fig.78): with this our example is in general agreement. As millesimals of length to 5th gill slit we find preoral length 337, length to level of rictus 551, width of mouth 382, anteroposterior length of nostril 112 oblique length 129, internarial minimum 146 maximum 337.

(c) *Girth of head.* Ten measurements of girth at equal intervals back to level of 5th gill slit are in mm 58 79 95 105 113 128 136 144 154 142. It will be seen they increase up to the last but one. On a loglog grid the ascendant 9 are significantly linear (t 128.909***) on 1-9. The extremely high t value can be regarded as fortuitous. Log G = 0.4367 log N + 1.7680. Predicted girths 59·75 95 107 118 128 137 145 153.

(d) *Head, length to vent, standard length.* On a loglog grid these 3 lengths are significantly linear (t 155.143**) on 1 2 3.
Log L = 1.3153 log N + 1.9486. Measured (predicted) lengths 89(89) 220(222) 378(377).

(e) *Disposition of fin origins and terminations.* On a loglog grid length to ventral origin, to first dorsal origin, to first dorsal termination, to anal origin, to second dorsal origin, to anal termination, to caudal origin (at commencement of anterior, here lower, caudal lobe) are significantly linear (t 4.622**) on 2 3 4 5 7 8 9 10. Measured (predicted) lengths as *TLs* 497(493) 587(586) 651(663) 735(727) 841(841) 883 (890) 923(926) 1 000(991). The agreement is striking, predicted values differing from measured by 0-7 mean 3.2 mm, or 0-2 mean 1.1%.

Parts XXIII (1977) and XXIV (1978) record equations specifying some of the above relations as found in some other sharks, *Carcharhinus greyi greyi* (Owen, 1853), *Sphyrna zygaena* (Linné, 1758), *Isurus oxyrinchus* Rafinesque, 1810.

Family Triakidae

The members of this world-wide group of some seven genera are distinguished from those of all other families represented in Australian waters by the following combination of characters: shape of head normal (i.e., not hammer-shaped, Sphyrnidae), shape of caudal normal (i.e., not with upper lobe greatly produced, Alopiidae), two dorsal fins, neither with a spine, the first wholly in advance of ventrals, an anal fin, caudal

peduncle without keels, teeth small, those in the side of the lower jaw flattened. Their closest relatives are the Carcharhinidae, from which they differ in lacking a true nictitating membrane and caudal pits and in the character of the teeth, in which last feature they approach the otherwise widely dissimilar Orectolobidae and Scyliorhinidae.

The Handbook (Munro 1956) recognizes five Australian species, of which two are noted as occurring in Tasmanian waters, *Mustelus antarcticus* Günther, 1870 (all States), *M. lenticularis* Phillipps, 1952 (Tasmania only). An additional species, *M. maugeanus* (Whitley, 1939) from Bass Strait, which appears to be inadequately differentiated, has not received general recognition, though maintained by its author in his Australian name-list (1964) in which (with Phillipps' species dropped and *M. ganearum* (Whitley, 1945) added) *Emissola* Jarocki, 1882 is preferred to *Mustelus* Linck, 1970.

Furgaleus ventralis (Whitley, 1943) hitherto known only from Western Australia and South Australia is here reported from this State.

KEY TO TRIAKIDAE RECORDED FROM TASMANIA

1. Teeth not forming a pavement; in upper jaw triangular with a central oblique cusp and 4 blunt serrations on outer side, in lower jaw more flattened. A median interdorsal ridge. Without white spots in adult. . . . . *Furgaleus ventralis*
   Teeth in both jaws forming a pavement. No median interdorsal ridge. With some white spots . . . 2
2. First dorsal originating above free end of upper pectoral border. Uniform grey with minute white spots. . . . . *Mustelus antarcticus*
   First dorsal originating above attached end of upper pectoral border. Grey with conspicuous larger white spots . . . . . *Mustelus lenticularis*

Genus *FURGALEUS* Whitley, 1951

Fur Whitley, 1943, *Aust. Zool.*, 10(2), p.167. Type-species, *Fur macki* Whitley.
Furgaleus Whitley, 1951, *Proc. R. zool. Soc. N.S.W.*, 1949/1951, p.67; substitute for *Fur* Whitley, 1943, preoccupied by *Fur* Jones, 1940 (Diptera).
Triakis: Stead, 1963, SHARKS RAYS AUST. SEAS, p.109; *non Triakis* Muller & Henle, 1838.

Furgaleus ventralis (Whitley, 1943)
(Fig.1; Plate 1)

Fur ventralis Whitley, 1943, *Rec. S. Aust. Mus.*, 7(4), p.397. Type locality: Off Bunbury, Western Australia.
Fur ventralis Whitley, 1944, *Aust. Zool.*, 10(3), p.259, fig.5; 1948, *Aust. Zool.*, 11(4), p.259, figs 1,2.
Furgaleus ventralis Whitley, 1964, *Proc. Linn. Soc. N.S.W.*, 89(1), p.33 and 1967, *Aust. Zool.*, 14(2), p.173: Munro, 1956, HANDBK AUST. FISH., 1, p.7, fig.40: Scott, 1962, MAR. FRESH WAT. FISH. S. AUST., p.29, unnumbered fig., p.29: Whitley, 1967, *Aust. Zool.*, 14(2), p.173: Scott, Glover & Southcott, 1974, MAR. FRESHW. FISH. S. AUST., p.33, unnumbered fig., p.33.

Note on synonymy

Mr Ian S.R. Munro, who has been good enough to provide some references not available here, has called my attention to the fact that the entry for Whitley's genus *Fur*, 1943 in the *Nomenclator Zoologicus* (Neave 1940, 5, p.100) cites *Rec. S. Aust. Mus.*, 7, p.167, in error for *Aust. Zool.*, 10(2), p.167; Neave's reference relates not to the

TABLE 1

GALEUS BOARDMANI (Whitley, 1928)

Dimensions in accordance with morphometric schema of Whitley (1943b) of a female, total length 488 mm, standard length (to origin of upper caudal lobe) 378 mm, from off Binalong Bay, east coast, Tasmania (Mr S. Down): dimensions in mm and in millesimals of standard length, *TLs*

No.	Dimension	mm	*TLs*
H1	Length of head to first gill slit	73	193
H2	Length of head to last gill slit	89	235
H3	Tip of snout to anterior margin of eye	29	77
H4	Breadth of snout immediately before eyes	35	93
H5	Snout tip to origin of pectorals	85	225
H6	Snout tip to origin of ventrals	188	497
H7	Eye, horizontal diameter	19.5	52
H8	Eye, vertical diameter (outside nictitating membrane)	12	32
H9	Interorbital	18	48
H10	Eye to spiracle	4.5	12
H11	Length of nostril [oblique]	12	32
H12	Internarial between posterior angles	13	34
H13	Preoral length	30	79
H14	Width of mouth (distance between angles)	34	90
H15	Labial fold, upper	7.7	20
H16	Labial fold, lower	7.0	19
H17	Height of first gill slit	9.5	25
H18	Height of last gill slit	8.5	22
B1	Length, tip of snout to origin of anterior [here upper] caudal lobe	378	1 000
B2	Length, tip of snout to middle of vent	203	537
B3	Predorsal length	220	582
B4	Depth at origin of first dorsal	33	87
B5	Breadth below origin of first dorsal	21	56
B6	Depth of caudal peduncle (immediately before origin of upper caudal lobe)	15.5	41
B7	Breadth of caudal peduncle (immediately before origin of upper caudal lobe)	11	29
B8	Claspers, outer margin to membrane	-	-
B9	Claspers, inner margin at base to membrane	-	-
F1	First dorsal, anterior margin	37	98
F2	First dorsal, base	26	69
F3	First dorsal, last ray	14	37
F4	Interdorsal space	72	190
F5	Second dorsal, anterior margin	42	111
F6	Second dorsal, base	31	82
F7	Second dorsal, last ray	12.5	33
F8	Second dorsal to origin of upper caudal lobe	29	77
F9	Anal fin, anterior margin	34	90
F10	Anal fin, base	41	108
F11	Anal fin, last ray	10.5	28
F12	Anal base to origin of lower caudal lobe	46	122
F13	Relative positions of second dorsal and anal (sketch)	-	-
F14	Pectoral, length	58	153
F15	Pectoral, base [anteroposterior extension]	26	69
F16	Origin of pectoral to origin of ventral	103	272
F17	Ventral, anterior margin	29	77
F18	Ventral, base [anteroposterior extension]	14.5	38

No.	Dimension	mm	*TLs*
F19	Ventral, last ray (measured externally, i.e., superiorly) [from membrane]	22	58
F20	Ventral origin to anal origin	90	238
F21	Caudal, upper lobe	118	312
F22	Caudal, lower lobe	40	106

holotype, *F. macki*, but to the present (second) species of the genus, described later the same year. In his 1951 paper cited above, in which he notes 'further study' of the *Nomenclator* has indicated the necessity for changing some generic names (including *Fur*) owing to their being preoccupied, Whitley strangely did not pick up this error.

Material

(a) A mutilated female (head, part of caudal fin removed; gutted), present total length from insertion of pectoral to origin of lower caudal lobe 783, off Wynyard, northwest coast, January 1979, Mr D. Batcheler (Q.V.M. Reg. No. 1979/5/1); 3 foetal specimens, about at full term, taken from (a), comprising (b) female *Ls* (length to origin of anterior, here lower, caudal lobe) 191 *Lt* 241, (c) male 191, 249, (d) male 187.5, 245.

Dimensions

The 'set of standard measurements for comparative and biometric studies of Australian sharks' proposed by Whitley (1943b) and employed by him in a number of his papers is here adopted. The full suite of dimensions is exhibited in table 2 for the 3 foetal specimens and for the type of *F. ventralis*, *Ls* 2 021 (Whitley 1943c) together with the 29 items reported for *F. macki* (Whitley 1943a) — the last-named described prior to the promulgation of the scheme: all these entries are given as millesimals of standard length (defined as in preceding paragraph; Whitley's original measurements in mm). In recording the dimensions of the type of *F. ventralis* Whitley added two items to his standard schedule (end of upper caudal lobe, upper edge of subcaudal notch); these were not noted earlier for *F. macki*, clearly being added in view of the comment that these two species exhibit 'minor differences in ... and outline of caudal': they are here included in the table.

Our large female *F. ventralis* being imperfect it is not possible to give those measurements that can be made as millesimals of standard length; they are, however recorded in table 2, being entered, unlike all other entries there, in mm.

It may be observed that entry F16 in Whitley's schedule 'Origin of pectoral to that of ventral' is superfluous, the measurement being directly derivable from H5 'Snout [tip] to origin of pectorals' and H6 'Snout [tip] to origin of ventrals'. Some minor alterations in wording and punctuation of the original schedule are here made.

The considerable length of the schema no doubt influenced its proposer to restrict fin measurements to lengths of anterior border base and last ray. Other dimensions of fins sometimes reported are here noted, those for the embryos being given in *TLs* units those for the (imperfect) adult in mm. First dorsal distal border 89 79 96 128 height 89 79 83 115. Second dorsal distal border 73 71 80 102 height 73 63 69 87. Anal distal border 47 52 53 52 height 45 42 48 60. Pectoral distal border 102 105 123 140 width 58 50 53 98 inner border 84 68 80 50. Ventral distal border 68 68 69 80.

Additional dimensions of the caudal fin, of taxonomic interest in the present context, include: subterminal notch to angle at junction of lower lobe and lower border of upper lobe 99 94 80, angle to tip of lower lobe 21 21 24, depth at notch 52 60 51, depth at junction of lower lobe and lower border of upper lobe 86 86 91, maximum width of fin at tip of lower lobe 102 115 127.

Embryos

The original account of *F. ventralis* (Whitley 1943c) was shortly followed (1944) by a brief note on some variations in the dental formula, accompanied by the first figure of the species prepared too late for inclusion in the initial notice. A third paper (1948) provided (in addition to observations on the commercial significance of the two species and two tables of selected dimensions) the first information on the reproductive cycle and the nature of the embryo. Later (1967, p.173) he noted of this species 'breeds at just over 4 feet' (1.2 m). The largest embryos noted, 11 30-45 mm long from a female about 1 200 long, possessed external gills and were attached to yolk sacs 76-95 by 33-40 mm. It was remarked it was not feasible to continue the studies on embryonic growth, 'and the size of the full-term embryo is unknown' Our specimens with a length some six times that of the largest examined by Whitley are at full-term. The yolk sac has been completely absorbed, the site of its attachment being marked by the small shallow umbilical slit (4 mm long in female, 5 in males) about at level at front of pectoral, or at 29.3 (female) 28.5 29.3 (males) percent of standard length.

Comparison of embryonic and adult specimens

A comparison of our foetal examples with the adult type reveals some interesting evidence of differences in relative growth and a marked dissimilarity in coloration.

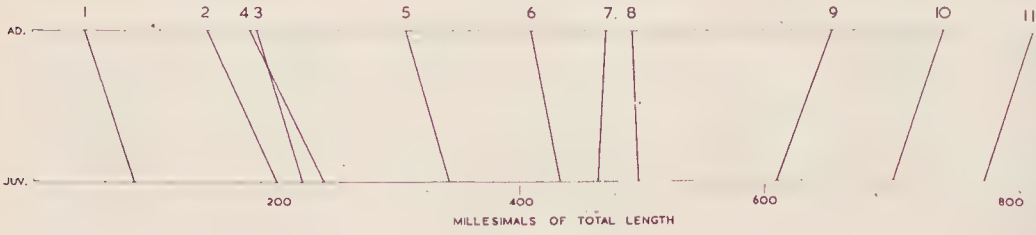


FIG.1.- *Furgaleus ventralis* (Whitley, 1943). Relative growth: increase with age in relative length of posterior part of body. Lengths to numbered points as millesimals of total length: upper line, holotype female, total length 1 250 mm, off Bunbury, Western Australia; lower line, arithmetic means for three full-term embryos, one female two males, total lengths 241, 245, 249, off Wynyard, northwest coast, Tasmania, January 1979. Points noted: 1 mouth, 2 first gill slit, 3 pectoral origin, 4 fifth gill slit, 5 first dorsal origin, 6 first dorsal termination, 7 ventral origin, 8 vent, 9 second dorsal origin, 10 second dorsal termination, upper caudal lobe origin ('standard length').

(a) *Relative growth.* An overall growth gradient along the whole length of the shark clearly obtains. As is evident from fig. 1, which shows the millesimals of total length at which certain important morphological landmarks are sited in the small individuals (mean values) and in the large individual, such landmarks from the mouth back to (and somewhat beyond) first dorsal origin are relatively more anteriorly located in the adult than in the embryos, while backward from the region of the origin of the ventral they lie relatively further caudad in the adult. Two minor anomalies are apparent. Whereas we find the length to the fifth gill slit greater than the length to pectoral origin, Whitley's measurements place the fin behind the slit (*cf.*, however, the original description of the species (Whitley 1943c, p. 397) in which it is noted the slit 'opens over the pectoral', and the later illustration (Whitley 1944, fig.5) in which the pectoral insertion appears the anterior point). Again, with the recorded measurements, while the insertion of the ventral fin is slightly more caudad

in the adult, the location of the middle of the vent is marginally more anterior. For the following set of landmarks, lengths to mouth first gill slit pectoral origin fifth gill slit first dorsal origin first dorsal termination ventral origin vent second dorsal origin second dorsal termination origin of upper caudal lobe the dimensions of the adult as percentages of the means of the embryos are 61.7 83.5 74.0 89.8 93.8 101.5 99.2 108.1 106.5 105.4.

In both the anterior set of 7 dimensions in which (apart from the anomalous length to pectoral origin) the *TLs* values exceed those of the adult and in the posterior set of 3 dimensions in which the reverse is the case the relation is an exponential one, growth being allometric. The rectified equations are given below (*A* = adult length *E* = embryonic length).

Log *A* = 1.2919 Log *E* — 0.7930. For the full set of 7 items *t* is 94.171***; with length to vent omitted 32.305*** with length to ventral origin omitted 90.936***, with in all cases *r* 0.998.

Log *A* = 0.8971 log *E* + 0.3204. The linear fit is (fortuitously) a virtually perfect one, with *r* 0.9999999 or *t* 14144.27.

In an extensive contribution to the biology of the species (including abundance, osteology, sex ratio, sex, weight, reproductive cycle) Whitley (1948, table 2) gave some means of total length head interdorsal space and length to origin of upper caudal lobe. Mean measurements of our embryos as *TLt* show these dimensions to be in them 1.35 0.70 0.95 those in the holotype adult.

(b) *Coloration.* In a key (Whitley 1943c, p.398) to the two species of *Furgaleus* the entry for *F. ventralis* is 'Coloration uniform', the couplet for *F. macki* reading 'Coloration transversely barred and with light spots.' However, while our adult specimen, with a general color of slate above white below and without noticeable markings, agrees well with the fairly detailed account in the description of the holotype, the embryos differ trenchantly, exhibiting a very conspicuous and well defined color pattern (plate 1)..

Dorsal surface with a number of broad dark slate cross bars separated by narrow cream or whitish lines and large rounded or subrectangular markings of the same color margined with lighter; in all specimens a whitish subcircular or longitudinally elliptical median spot just in front of eyes. Lateral surface with extensions on to its upper one-fifth to one-third of most of dark markings of dorsum; below or between these numerous dark spots and patches of varying shapes and sizes partly or wholly separated by lighter patches of lines (latter tending, particularly behind first dorsal, to form a partly interrupted narrow longitudinal band), some dark spots more or less annulated with lighter. Ventral surfaces whitish or creamy, immaculate. Both dorsals with most of distal half occupied by a large ovoid dark spot narrowly bordered externally with whitish, smaller dark spot on proximal part of anterior border and dark or darkish triangle on lower hind tip. Anal and ventral dusky in distal two-thirds with more or less distinct dark spot in front part of this area; lower surface of ventral more or less dusky in distal half. Pectoral with large dark patch in distal two-thirds bordered with lighter, one dark spot at front of base another at end of base the latter continuous with, but noticeably darker than, the large marking; lower surface dusky in distal half. Upper border of caudal with four dark rounded or ovoid spots followed behind by a light-margined dark marking occupying most of fin behind notch, three or four dark spots or smudges along lower border. Iris dark bluish, pupil white or pale bluish; orbit narrowly bordered with whitish in front above and behind, dusky below.

Though some individual variation is evident the overall pattern shows a high degree of consistency. No consistent difference between the female and two males is apparent.

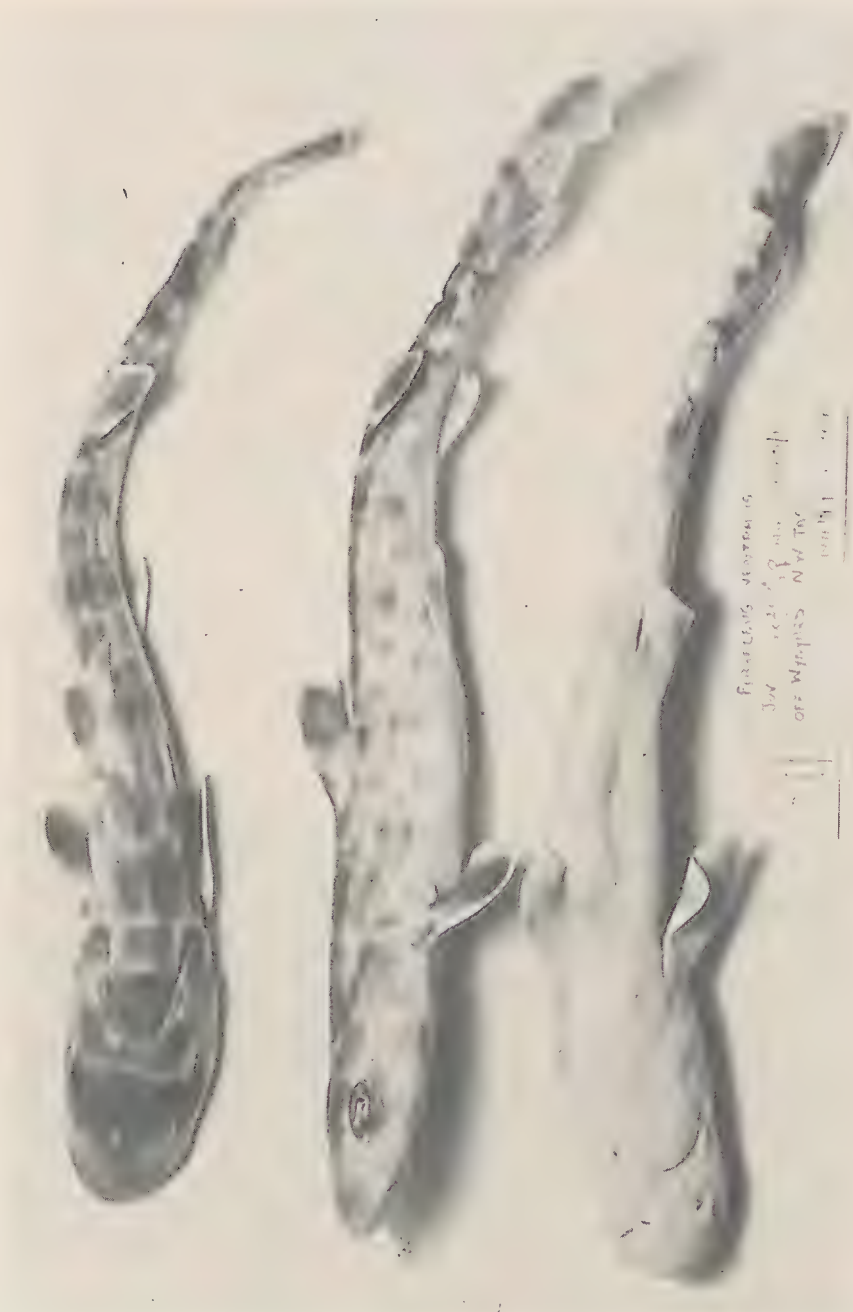


PLATE 1.- *Furgaleus ventralis* (Whitley, 1943). Three full-term embryos (parent taken off Wynyard, northwest coast, Tasmania, January 1979), total length 241-249 mm, top and middle specimens males bottom specimen female — showing colour pattern (not present in adult) and general features. Photograph R.H. Green).

Comparison with *F. macki*

The key provided (Whitley 1943c, p.398) in the description of *F. ventralis* to separate it from the earlier-described *F. macki* involves four characters as follows (*F. macki* here cited first): (a) ventral origin below posterior lobe of first dorsal fin, behind level of fin (b) a marked (no) gibbosity predorsally (c) no (an) interdorsal ridge (d) transversely barred and with light spots, coloration uniform. It is of interest to note that in these characters other than (b) the embryos of *F. ventralis* are closer to the adult *F. macki* than to the adult *F. ventralis*. Thus (a) ventral originates below tip of posterior lobe of first dorsal, being behind it in adult by a distance exceeding half length of dorsal base (Whitley 1944, fig.5) (c) no interdorsal ridge developed, though its presumed site is detectable on examination with a lens, being indicated by a faint line somewhat lighter than the ground color (d) with distinctive color pattern. Further, the adult head viewed in plan as represented in Whitley's illustrations is decidedly more pointed in *F. ventralis* (1944, fig.5; 1948, figs 1 2) than in *F. macki* (1943a, fig.1) that of our embryos more closely resembling the latter (see below).

In the available material the same trans-species resemblance extends to certain ratios defining general body form. In the following examples the *TLs* figures are the mean for the embryos and the values for the holotypes of *F. macki* and *F. ventralis* in that order : snout 97 81 70; preoral length 109 88 64; length to fifth gill slit 306 257 215; predorsal length 437 388 372; interdorsal 225 245 223; width of mouth 91 76 66, length of upper caudal lobe 277 245 223. As shown above in *F. ventralis* proportional lengths to points along the anteroposterior axis of the shark are a function of overall length. As the holotype of *F. ventralis*, a female 1 250 mm in total length, is longer than the holotype of *F. macki*, an immature male 500 mm in total length, differences in the first five dimensions noted above may be, at least in part, size related.

Some aspects of form

(a) *Head, length to vent, standard length.* As has been found to be the case in some other sharks (and in some teleosts) the lengths of head (to fifth gill slit), head plus trunk, head plus trunk plus tail (to origin of caudal) are such that in a loglog plot they occur on integral abscissal values, most commonly, as here, on 1 2 3. Statistics for our three foetal examples of *F. ventralis* and for the adult type of that species, together with some estimated results for the holotype of *F. macki*, are set out in that sequence below, all dimensions being millesimals of standard length.

Log L = 1.0800 log N + 2.4791; t 46.415*; measured (predicted) lengths 304(301) 623(637) 1000(987).

Log L = 1.0793 log N + 2.4832; t 104.586**; 305(304) 639(643) 1 000(996).

Log L = 1.0673 log N + 2.4899; t 206.831**; 309(309) 645(647) 1 000(998).

Log L = 1.4020 log N + 3.3367; t 43.239*; 242(244) 614(600) 1 000(1 015).

The greater slope in the type is indicative of the more rapid rate of growth in the posterior part of the shark noticed above in the comparison of the embryos with the adult; a similar increase is evident in the next set of equations (the concomitant greater magnitude of the independent term is of course attributable to the greater length of the adult).

While length of head and length to caudal origin ('standard length') are recorded for the type of *F. macki* the table of measurements provided does not include length to vent or the subequal length to ventral origin. By interpolation the equation in the next section for the disposition along the general anteroposterior axis of those fin origins for which length-to measurements are available (Whitley 1943a, p.169) gives length to ventral 247 mm or, by proportional adjustment based on data for *F. ventralis*, length to vent 258. If this datum is accepted the resultant calculation for *F. macki* is as follows.

Log L = 1.2959 log N + 2.3881; t 35.112*; 242(244) 614(600) 1 000(1 015).

(b) *Location of fin origins.* Lengths from tip of snout to the origins of all six fins are such that in a loglog context they fall when taken in sequence caudad on abscissal integral values of 1 2 4 6 7 10 to yield a linear function. Dimensions below as *TLs*.

Log L = 0.5436 log N + 2.4565; t 49.709***; measured (predicted) lengths 283(286) 429(427) 592(608) 764(758) 825(824) 1 000(1 000).

Log L = 0.5498 log N + 2.4563; t 38.094***; 280(286) 435(419) 597(613) 780(766) 838(834) 1 000(1 014).

Log L = 0.5327 log N + 2.4719; t 26.304***; 291(296) 448(429) 592(620) 800(770) 832(836) 1 000(1 011).

Log L = 0.6542 log N + 2.3644; t 27.675***; 225(231) 372(364) 572(573) 801(747) 810(826) 1 000(1 044).

For *F. macki* only the lengths to origins of first dorsal second dorsal anal and caudal are available; with these data.

Log L = 0.5935 log N + 2.4124; t 51.787*** (d.f.2); —— 164(163) —— 313(317) 345(348) 426(420) ——.

(c) *Head in plan.* It has been noted above that on the basis of illustrations the snout viewed in plan is more pointed in *F. ventralis* than in *F. macki*. Using 10 measurements taken at equal intervals between tip of snout and level of front of mouth polynomials have been calculated for a male and a female embryo of the former species and are noted below —— to permit of direct comparison between these and individuals of different size widths are expressed as percentages of length to level of front of mouth. N is serial number of measurement counting back from snout tip.

Male. $W = 39.38 + 20.175\ N - 1.0360\ N^2$; R 0.9919; measured (predicted) widths 56.0(58.5) 76.5(75.6) 91.5(90.6) 104.5(103.5) 115.0(114.4) 122.5(123.1) 131.0(129.8) 134.5(134.5) 135.5(137.0) 137.5(137.5). A slightly better fit, R 0.9922, is obtained by the addition of a term, $W = 36.6 + 22.843\ N - 1.6236\ N^2 + 0.03506\ N^3$, yielding predicted values 57.6 72.8 91.2 104.0 114.4 122.6 128.7 133.1 136.0 137.5.

Female. $W = 49.62 + 19.325\ N - 1.0626\ N^2$; 0.9965; 65.0(67.9) 85.5(84.0) 100.5(98.0) 110.5(109.9) 121.0(119.7) 126.5(127.3) 130.5(132.8) 135.0(135.5) 137.0(137.5 138.5(136.6). The addition of the N^3 term improves R to 0.9997; $W = 39.60 + 28.212\ N - 2.9895\ N^2 + 0.11678\ N^3$, yielding predicted values 64.9 83.0 100.5 112.1 120.5 130.7 133.7 139.6 139.6.

Comparable equations derived from figures of the female holotype of *F. ventralis* (Whitley 1944, fig.1) and the male holotype of *F. macki* (Whitley 1943a, fig.1) are provided for comparison with the Tasmanian embryos of the first species. While a high degree of accuracy cannot be looked for in such data a tolerably clear picture of the outline of the snout in plan emerges from it.

F. ventralis. $W = 13.72 + 5.445\ N^2$ (R 0.9981) or $W = 11.46 + 7.448\ N - 0.66517\ N^2 + 0.26321\ N^3$ (R 0.9994).

F. macki. $W = 39.30 + 16.998\ N - 0.91667\ N^2$ (R 0.9873) or $W = 25.31 + 29.407\ N - 3.6071\ N^2 + 0.16306\ N^3$ (R 0.9976).

By differentiation of the second-degree equations the tangents to the outline of the head in plan are found to be for *F. ventralis* in male embryo female embryo adult female (estimated from figure) 2.07 2.13 0.43, for *F. macki* in male adult (estimated from figure) 1.83. Thus the present data suggest that in *F. ventralis* the head becomes more obtuse with age, and indicates the degree of pointedness in the embryos of *F. ventralis* is (like certain other characters noted above) closer to that in *F. macki* than to that in the adult of their own species.

TABLE 2

FURGALEUS VENTRALIS (Whitley, 1943)

Dimensions of (a) an imperfect female from near Stanley, northwest coast, Tasmania, (b) female (c) male (d) male, three embryos, standard lengths 191 191 187.5 mm, taken from (a); together with (e) female holotype of *F. ventralis* standard length 1 021 mm, and (f) male holotype of *F. macki* (Whitley, 1943), standard length 420 mm. Dimensions of (a) given in millimetres, of all other specimens as thousandths of standard length (*TLs*).

			F. ventralis				*F. macki*
		(a)	(b)	(c)	(d)	(e)	(f)
		mm	*TLs*	*TLs*	*TLs*	*TLs*	*TLs*
H1	Length of head to first gill slit		259	251	259	175	202
H2	Length of head to fifth gill slit		304	306	309	215	257
H3	Tip of snout to anterior margin of eye		94	94	101	70	81
H4	Breadth of snout immediately before eyes		136	147	139	88	
H5	Snout tip to origin of pectoral		283	280	291	225	
H6	Snout tip to origin of ventral		592	597	592	572	
H7	Eye, horizontal diameter		57	62	60	26	38
H8	Eye, vertical diameter (outside nictitating membrane)		36	37	35	11	17
H9	Interorbital		113	115	115	68	79
H10	Eye to spiracle		16	17	19	13	
H11	Length of nostril, anteroposterior oblique		21, 38	21, 37	24, 37	21	
H12	Internarial, between posterior angles		60	65	59	31	38
H13	Preoral length		105	110	112	64	88
H14	Width of mouth (distance between angles)		93	90	92	66	76
H15	Upper labial fold		42	39	37	25	
H16	Lower labial fold		21	21	20	15	
H17	Height of first gill slit		26	24	26	22	
H18	Height of fifth gill slit		17	13	13	19	
B1	Length from snout tip to anterior [lower] caudal root		1 000	1 000	1 000	1 000	1 000
B2	Length from snout tip to middle of vent		623	639	645	598	
B3	Predorsal length		429	435	448	372	388
B4	Depth at origin of first dorsal		141	147	149	168	171
B5	Breadth below origin of first dorsal		141	136	117	144	
B6	Depth of caudal peduncle before caudal origin	36	47	52	51	38	
B7	Breadth of caudal peduncle before caudal origin	30	37	36	37	29	
B8	Claspers, outer margin			25	29		
B9	Claspers, inner margin to membrane at base			26	29		
F1	First dorsal, anterior margin	170	157	168	152	126	140
F2	First dorsal, base	127	110	120	128	123	110
F3	First dorsal, last ray	63	47	52	59	51	60
F4	Interdorsal space	295	225	225	224	306	245
F5	Second dorsal, anterior margin	142	147	147	137	137	138
F6	Second dorsal, base	115	120	126	120	112	105
F7	Second dorsal, last ray	38	37	42	45	40	45
F8	Second dorsal to base of caudal	113	115	115	120	117	140
F9	Anal, anterior margin	115	115	115	109	103	105
F10	Anal, base	90	83	89	93	88	74
F11	Anal, last ray	30	37	34	35	31	31

		F. ventralis				*F. macki*	
		(a) mm	(b) TLs	(c) TLs	(d) TLs	(e) TLs	(f) TLs
F12	Anal base to base of caudal	85	86	89	101	102	98
F14	Pectoral, length	175	157	165	171	163	152
F15	Pectoral, base, anteroposterior oblique	60, 62	47, 52	49, 52	49, 54	59	48
F17	Ventral, anterior margin	100	99	94	107	78	83
F18	Ventral, base, in male to outer angle of clasper	71	29	68	69	65	60
F19	Ventral, last ray, measured externally	62	58	52	56	45	48
F20	Ventral origin to anal origin	242	202	204	213	238	
F21	Caudal, upper lobe		267	280	285	223	245
F22	Caudal, lower lobe	125	144	134	136	113	100

Family XENOCONGRIDAE

By the generality of Australian authors — e.g., Lucas (1890) Ogilby (1916) McCulloch (1911, 1929) Whitley (1944, 1958, 1962) Munro (1957a, 1967) Scott (1962) Scott et *al.* (1974) — a tolerably compact regional assemblage of Worm Eels has been treated as the family Echelidae, a course hitherto followed in contributions in the present series, Part III (1936) VI (1953) VIII (1957) X (1961) XI (1963) XIX (1974a) XXI (1975) XXII (1976). In both of the early Tasmanian catalogues of Johnston (1883, 1891) the wide Guntherian Muraenidae is used, while among recent authors Marshall (1964) dealing with Queensland fishes adopts Myridae and in Allen *et al.* (1976, relevant section by Hoese) in a checklist of the fishes of Lord Howe Island the characteristic genus *Muraenichthys* is listed in Ophichthidae. In their provisional outline classification of living teleosts Greenwood *et al.* (1966) abandon Echelidae, sharing it out between Xenocongridae (along with Chlopsidae, Myridae in part, Muraenichthyidae, Chilorhinidae) and Ophichthidae (Ophichthyidae, Myrophidae, Myridae in part): this usage is adopted here.

Two species only are credited to Tasmania in the Check-List (McCulloch 1929), *Muraenichthys breviceps* Günther, 1876 and *M. tasmaniensis* McCulloch, both with this State as type locality. *M. australis* Macleay, 1881 (type locality New South Wales) *M. ogilby* Fowler 1908 (type locality Victoria) and *M. lingowenah* Scott, 1975 (known only from Tasmania) were added to the local list in Parts III (1936) XIX (1974a) XIX (1975) respectively. A new species of *Muraenichthys* is here described.

Genus *MURAENICHTHYS* Bleeker, 1853

Muraenichthys Bleeker, 1853, *Natuurk. Tijdschr. Ned-Ind.*, 4, p.505. Type-species, *Muraenichthys gymnopterus* Bleeker (designated 1864).
Muraenichthys: Schultz, 1953, *U.S. Nat. Mus. Bull.*, 202, p.70 (references and synonymy). Date of genus

The genus *Muraenichthys* is commonly attributed in Australian and New Zealand texts, including the present studies, to Bleeker, 1864, *Nat. Tijdschr. Dierk.*, 2, p.117 [date in Australian Check-List (McCulloch 1929) cited as 1865]. The reference given above is that listed in Neave (1940).

Subgenus *MURAENICHTHYS* Schultz, 1953

Muraenichthys Schultz, 1953, *U.S. Nat. Mus. Bull.*, 202, p.71 (in key) subgenus of *Muraenichthys* Bleeker, 1853.

Muraenichthys (Muraenichthys) lengomena, sp. nov.
(fig. 2)

Diagnosis

Attenuate, depth about 50 in length; dorsal originating behind head by less than head length; Schmidt's index 29-30; head 4-5 in trunk, 12-14 in total length; precaudal length 1.3-1.4 in tail; eye 5-6 in snout; snout pointed, upper jaw the longer; maxillary and vomerine teeth uniserial; dorsal and anal fins low, caudal vestigial, pectoral and ventral lacking; trunk above lateral line greenish with very numerous dark brown punctulations, yellowish below, the former color gradually extending downward on most of tail, the terminal portion lighter than the rest approaching white; no gross markings.

Material

Three specimens, (a) total length 232.5 mm (b) 153.5 (c) imperfect posteriorly 87+, dredged in 25 fathoms (46 m) off Eddystone Point, east coast, Tasmania on 22 June 1975 by Mr Shane Down. Deposited at the Queen Victoria Museum and Art Gallery, Launceston, Tasmania (a) Holotype Q.V.M. Reg. No. 1979/5/68, Type No. 368. (b) Paratype Q.V.M. Reg. No. 1979/5/76, Type No. 369. (c) Paratype Q.V.M. Reg. No. 1979/5/77, Type No. 370.

Principal dimensions

Dimensions in this paragraph are given as millesimals of total lengths (232.5 153.5 —) with absolute measurements, mm, in parentheses. Length to dorsal origin 127 (29.5) 137 (21.0) — (15.9), to vent (middle) 422 (98.0) 43.3 (66.5) — (46.2), to anal origin 438 (101.8) 44.5 (68.3) — (47.4). Head 73 (16.9) 85 (13.0) — (9.0). Maximum depth of head 19 (4.3) 2.0 (3.1) — (specimen distorted), maximum depth of body 15 (3.5) 19 (2.9) — (1.9), depth at vent 13 (3.1) 13 (2.0) — (1.7).

Dimensions in this paragraph are lengths in length of head (absolute measurements, mm, in parentheses). Eye (0.5 0.4 0.2) 33 33 45. Snout (3.0 2.0 1.4) 5.6 6.5 6.4. Interorbital (2.3 1.7 1.0) 7.4 7.6 9.2. Mouth cleft from tip of lower jaw to angle of free gape (3.2 2.7 1.4) 5.3 4.8 6.4, to end of rictal groove (5.0 4.0 3.0) 3.4 3.3 3.0.

Proportions

Maximum depth 4.8 4.5 4.7 in head. Head 13.8 11.8 — in total length, 4.8 4.1 4.1 in trunk. Eye 6.0 5.0 7.0 in snout, 4.6 4.3 5.0 in interorbital. Total mouth cleft 5.3 4.8 6.4 in head.

To the above proportions commonly recorded in species descriptions may be added the following four ratios that have been found in these studies to be of diagnostic value and that are set out in a comparative schedule in Part XXI (1975, table 1). Head in dorsal-bearing trunk 4.05 3.50 3.37. Precaudal length in tail 1.37 1.31 — Predorsal trunk in total trunk 1.57 1.64 1.75. Predorsal length in rest of length 6.88 6.31 —.

Schmidt's index ($S = \frac{a-d}{t} \times 100$, where a = length to vent d = length to dorsal origin t = total length) 29.5 29.6 —.

General features

Highly elongate, slender, depth 53-66 in length, subcylindrical throughout greater part of length becoming somewhat compressed posteriorly. Branchial basket well developed, convex, projecting more ventrally than laterally, its length subequal to interval between its origin and front of eye, the forwardly convex rays about 30, groove between branchiostegals traceable forward to level of eye. Gill opening small, diameter less than that of eye, about midway between ventral profile and lateral line, the latter here about equidistant from dorsal and ventral profiles. Head small 4-5 in trunk, 12-14 in total length; mostly subcyclindrical, tapering from eye to fairly acute, more or less evenly rounded snout tip. Snout more rounded dorsally than ventrally, its

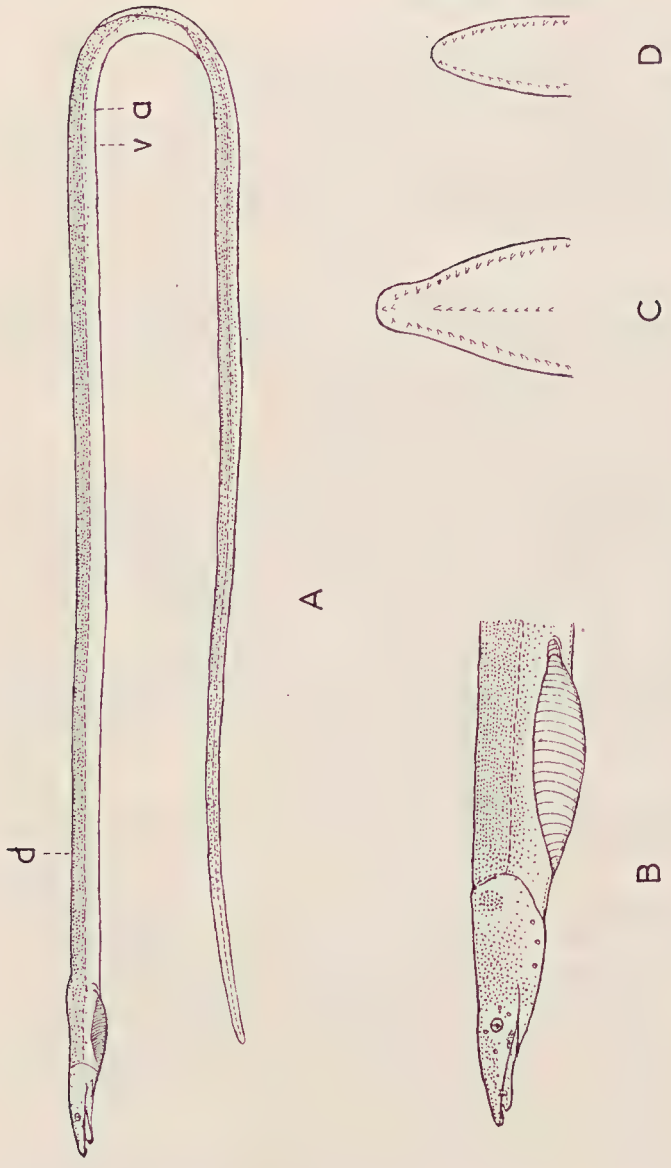


FIG. 2.- *Muraenichthys (Muraenichthys) lengomena sp. nov.* Holotype, total length 232.5 mm, dredged in 25 fathoms (46 m) off Eddystone Point, east coast, Tasmania, 22 June 1979 (Queen Victoria Museum Reg. No. 1979/5/68; Type No. 368). A, Lateral aspect, x 1 1/3: fins wholly lapsed; a, anal origin, d, dorsal origin, v, vent (middle). B, Head, lateral aspect, x 4. C, Dentition, upper jaw and vomer, semidiagrammatic, x 7. D, Dentition, lower jaw, semidiagrammatic, x 7.

length 5-7 eye, 6-7 in head. Upper jaw the longer and wider, its width anteriorly more than twice, posteriorly about one and a quarter that of lower jaw; latter fitting against palate when mouth is closed behind a pad formed by the strongly convex ventral surface of the upper jaw. Anterior nostril in upper lip briefly tubular, overhanging lower jaw barely behind its tip. Posterior nostril a slit in upper lip just in advance of eye, overhung by a small downwardly directed flap. Eye small circular about equidistant from mouth cleft and dorsal profile, iris black pupil bluish, the pigmented organ encircled by a slightly elevated annulus lighter than immediately adjacent area, its diameter 2-3 that of eye. Interorbital convex, strongly transversely moderately anteroposteriorly 4-5 times eye. Free gape extending about to level of posterior border of eye, rictal groove continuing back as far again.

Several large teeth on the premaxilla. Maxillary and mandibular teeth uniserial, rather large well spaced tending to decrease in size posteriorly. Teeth on vomer in a single series of about 10, decreasing in size posteriorly, the anterior almost twice as large as the posterior.

Lateral line a low narrow continuous or subcontinuous ridge in places presenting short irregular contiguous extensions associated with local waviness; originating

behind eye by about a snout length, equidistant from dorsal and ventral profiles, in part of trunk rising somewhat, thereafter continuing about equidistant from profiles; the anterior ends of the two lines joined by a slightly forward convex arc across occiput. Dorsal and anal fins almost wholly lapsed into grooves, evidently low; confluent with a minute anal fin, somewhat more distinct in larger paratype.

Coloration

(a) *Trunk.* Lateral surface above lateral line somewhat yellowish green, the color quite continuous with outer portion of the dorsal surface, the middle one-third or slightly less of which is occupied by a tolerably sharply demarcated band of dusky greenish; below lateral line distinctly more yellowish, the colour extending with little variation on to whole of ventral surface in most of trunk but very gradually become somewhat lighter in the anterior portion. A very narrow band of brighter yellow immediately below lateral line, itself yellowish. Side above lateral line and dorsal surface minutely and densely punctulated with brownish, this punctulation serving to accentuate the difference between upper and lower half flank, the chromatophores extending fully down to the lateral line, then ceasing abruptly save for about a head length in advance of vent where a few well separated punctulations, never constituting more than a single line, descend below the lateral line.

(b) *Tail.* In general similar to trunk, differing from it as follows: the extension of the brown chromatophores below the lateral line becomes progressively more pronounced caudad, most of flank being involved by middle of tail; the median dusky dorsal band becomes less conspicuous almost to vanishing point; for more than a head length in advance of its tip almost or wholly lacks the brown chromatophores, appearing overall much lighter than rest of fish, approaching white.

(c) *Head.* Holotype behind operculum similar to trunk; a brownish spot on upper front of operculum, region behind and below it without punctulation; whole of snout dark brownish, this color extending back on dorsum, somewhat decreasing in intensity, to cover interorbital. Smaller paratype with dark brown spot on occiput, snout a trifle darker than rest of head. Larger paratype with whole head without discrete markings, a trifle lighter than trunk, tip of snout almost white.

Affinities

The seven species of *Muraenichthys* accepted as valid in the Handbook (Munro 1957a) — of which five are now recorded for Tasmania — together with the two endemic species described in Part XXI and here are divisible into two distinct groups on the basis of the location of the origin of the dorsal fin. A convenient quantitative specification of this location arrived at by subtracting length to dorsal origin from length to vent, dividing by overall length of fish and expressing the result as a percentage was first introduced by Schmidt in his classical studies on eels, being effectively used by him in the separation of the long-finned and short-finned eels of eastern Australia (1928). Formally designated Schmidt's index and denoted by *S* by the writer (1953) this formula has been found to be a useful tool in other groups, and is of prime importance in the taxonomy of the present family, the members of which exhibit in most somatic features a marked overall similarity.

Australian species with the dorsal fin originating behind the vent, the index thus having a negative value, are *Muraenichthys australis* Macleay, 1881, with *S* ranging (Part XXI, 1975, p.134) from — 1.10 to — 2.46, *M. tasmaniensis* McCulloch, 1911 from — 2.6 to — 4.4 (in holotype of the Western Australian *M. t. smithi* (Whitley, 1944) *ca* — 7.4) and *M. iredalei* Whitley, 1927 (no appropriate data available): the first two only have been reported from Tasmania. Of the remaining six species two not found in this State are *M. devisi* Fowler, 1908 (Victoria) and *M. godeffroyi* Regan, 1909 (Queensland): in the absence of the relevant measurements it is not possible to

calculate accurately values of *S* for these two forms; however from proportional dimensions supplied it would appear these are round about 23 and round about 19, respectively. Available values of *S* for the three locally occurring echelids hitherto described with the index positive are: *M. breviceps* Günther 1876 19.1-21.9, *M. ogilby* Fowler, 1908 18.7-20.7, *M. lingowenah* Scott, 1975 1.6 (unique holotype). (The two species with intersecting values of *S* and with very similar morphometric characters in general are trenchantly separable by the dentition, Günther's species having teeth in the jaws in a single series and those on the vomer in three series, while Fowler's species has teeth triserial in the jaws (biserial laterally) and biserial on the vomer).

For the present species *S* = 29.5 (holotype) 29.6. Though the species value of *S* is subject to an excess of several units, the clear excess of these values over the highest figure for any other known Australian species satisfactorily serves to identify the present form. The magnitude of the index has been found to be positively correlated with length of fish; for 8 individuals of *M. breviceps* with *Lt* 234.8 - 583.0 r = 0.918 (z = 1.578) with t = 5.677** (Part XXI, 1975, p.132).

The following four body-ratios serve to distinguish the present species from one or more of the locally occurring species; values are given in succession for *M. lingowenah* (holotype) *M. ogilby* (range 21 specimens) *M. breviceps* (range 8 specimens) *M. lengomena* (holotype and 1 or 2 paratypes).

Head in dorsal-bearing trunk: 0.23, 2.03-2.43, 2.17-2.90, 4.05 3.50 3.40.
Precaudal length in tail: 1.24, 1.47-1.75, 1.63-1.80, 1.37 1.31 —.
Predorsal trunk in total trunk: 1.05, 2.27-2.87, 3.10-3.60, 1.57 1.65 1.75.
Predorsal length in total length: 1.32, 4.62-4.94, 4.59-5.20, 6.88, 6.31 —.

In having the teeth uniserial both in the jaws and on the vomer (an arrangement conveniently denoted 1 1) *M. lengomena* agrees with the three species, *M. australis*, *M. tasmaniensis* and *M. iredalei* that constitute the group otherwise trenchantly marked off by having *S* negative. Among the remaining Australian species, of which the first three occur locally, the dental arrangements are as follows (figure in parentheses is number of rows in hinder part of jaw): *M. breviceps* 1 3, *M. ogilby* 3 (2) 2, *M. lingowenah* 1 (2) 2, *M. devisi* 2 (1) 1, *M. godeffroyi* 2.2 — hence the present species stands wholly apart in dentition from all other described species in which *S* is positive.

In being largely bicolor with the darker component rather sharply bounded below by the lateral line back to or beyond the vent, thereafter gradually descending to the ventral profile *M. lengomena* conforms to the modal pattern of the genus as represented in Australia (*M. godeffroyi* is described as of uniform coloration); the presence in the darker region of abundant punctulation also is a general feature. However the presence of a noticeably lighter terminal segment in the tail has not elsewhere been reported and does not occur in any local material examined by the writer.

The second binomen *lengomena* is one of the two words for eel recorded in Milligan's vocabulary of the extinct Tasmanian Aborigines (Ling Roth 1899) — shown with an acute accent on the initial *e* by Plomley (1976)— being used by tribes from Oyster Bay to Pittwater. A dialectal variant, *lingowenah*, recorded for tribes about Mount Royal, Bruny Island, Recherche Bay and the south of the island has been adopted for an endemic species of this genus described in Part XXI (1975).

Family OPHICHTHYIDAE

The snake eels or serpent eels are at once distinguished from the worm eels (Echelidae) congers (Leptocephalidae) morays (Muraenidae) and typical eels (Anguillidae) in having the dorsal and anal fins if present ending in front of the tail tip, which projects as a stiff point (said to serve as a burrowing organ). Of the 11 species

listed in the Handbook (Munro 1957a) only 2 are known to occur outside Queensland, Northern Territory and Western Australia, *Malvoliophis pinguis* (Günther, 1873), referred in the Check-List (McCulloch 1929) to *Bascanichthys* Jordan & Davis, 1892, from southern Queensland, New South Wales, and *Ophisurus serpens* (Linné, 1758), from New South Wales, Western Australia and Tasmania. The species occurring locally differs trenchantly from other Australian forms by its longer mouth cleft (2, *cf.* ⩾3, in head).

Genus *OPHISURUS* Lacépède, 1800

Ophisurus Lacépède, 1800, HIST. NAT. POISS., 2, p.195. Type-species, *Ophisurus serpens* Lacépède = *Muraena serpens* Linné.

Ophisurus serpens (Linné, 1758)

Muraena serpens Linné, 1758, SYST. NAT., ed. 10, p.244: based on Artedi, gen 24, syn.41
Type locality: southern European seas.

Occurrence in Tasmania

Ogilby (1897a) observed of a Tasmanian eel it 'belongs to the restricted genus *Ophisurus*, but it is in such bad condition that the species cannot be determined. It may, however, be included in the Tasmanian catalogue as *O. serpens*.' Later (1897b), p.159, footnote) he accepted fully the specific determination. Lord & Scott (1924, p.37) remarked 'As regards the right of this species to appear upon the Tasmanian faunal list, we know of no further records of specimens beyond the reference [1897a] made by Ogilby.' A confirmatory record is given in Part XI (1963), in which some observations are made on a specimen, *Lt* 1 144, taken in a lagoon near the mouth of the George River, east coast, in August 1956. An additional example, *Lt* 601, hooked at Scamander, east coast, by Mr G. Viney on 12 May 1979 (Q.V.M. Reg. No. 1979/5/46) is here reported.

Dimensions as *TLs*

Head 68.2. Snout from tip of upper jaw 16.8, lower jaw 14.3. Eye 6.67. Interorbital 6.49. Length of mouth cleft 34.8. Length to origin, termination of dorsal 104 975, of anal 356 983. Length to pectoral 71.5, length of fin 14.5. Length to vent (middle) 344. Depth (width) at front of eye 9.7(7.0) back of eye 11.3(8.3) end of mouth cleft 16.5(14.6) gill slit 20.0(15.8) vent 15.1(16.3) anal termination 7.15(6.50); maximum head 21.6(15.8) body 16.6(16.6).

Proportions

Values for the 5 proportions given in the Handbook (Handbook values in parentheses) are as follows. Mouth cleft in head 2.0(2). Eye in snout, upper jaw 2.53 lower jaw 2.15(2.9). Head in trunk 4.05(3.6-5.2). Head in tail 9.61(7.1). Pectoral in head 4.71(6).

Dentition

The taxonomic importance of the dentition of Ophichthyids has been amply demonstrated by Schultz (1953). The pattern in the present specimen comprises clustered premaxillary, uniserial maxillary, dentary and vomerine sets. Premaxillary: lateral 3 pairs (second tooth missing on right side), large subconical recurved acute decreasing in size backward; medial 1 small, just behind level of hindmost premaxillary. Maxillary: in either jaw a single series of about 40, small subconical somewhat recurved rather bluntly pointed, largest near middle decreasing slightly anteriorly somewhat more markedly posteriorly. Vomerine: an anterior line of 3 large acute strongly recurved, first just behind premaxillary median, followed after a short diastema by a series of about a dozen decreasing in size backward; unless the mouth is flattened by moderate pressure the hind part of the series is hidden where 2 palatal folds meet over a median groove. Dentary: on each side 2 large recurved acute well spaced followed by a uniserial set of about 40, all small the posterior only half the size of the anterior.

The present specimen differs from the earlier individual chiefly in having 3 instead of 2 pairs of premaxillary teeth and only 3 instead of 6 large spaced teeth at the front of the vomerine series.

A blade of a brown seaweed about 2 mm wide projected for about 10 mm from the mouth and extended for about 60 mm down the gullet.

Coloration

Head down to level of lower orbital rim, trunk on upper four-fifths, tail above lateral line intensely minutely punctulated with brownish, overall olivaceous darkest dorsally; below this lighter somewhat silvery. Ventral surface of head and trunk lustrous silver, increasingly less brilliant more admixed with pale greenish behind vent. Terminal 2-3 mm of tail dusky. Dorsal and anal (wholly collapsed) narrow lines of dark greenish, dorsal bordered on either side by slender pale greenish strip devoid of all punctulation. Pectoral brownish green barely darker than flank.

Head, length to vent, total length

In this family the total absence of a caudal fin renders standard length (the diemnsion conventionally used in the present context) and total length virtually the same. In a loglog plot length of head, length to vent and total length are significantly linear on 1 2 3, both for the present specimen (t 31.22*) and for the larger individual noted in Part XI (t 36.507*). In the equations below (present fish first) dimensions are millesimals of total length.

Log L = 2.4325 log N + 1.8258. Measured (predicted) lengths 68(67) 344(361) 1 000(969).

Log L = 2.3360 log N + 1.8743. Lengths 76(75) 363(378) 1 000(974).

Location of dorsal and anal origins

In a loglog plot the lengths to the origins of the dorsal and anal fins and the total length are significantly linear (t 31.191*, 58.336*) on 2 5 10.

Log L = 1.4030 log N + 1.5875. Measured (predicted) lengths (*TLs*) 104(102) 356(370) 1 000(978).

Log L = 1.2518 log N + 1.7433. Lengths 133(132) 407(415) 1 000(989).

The effective constancy of the fin origins may be noted. With their relative (exponential) lengths along the general axis constant, the magnitude of the intercept will increase proportionately with increase in size of fish: the ratios here of intercept to the logarithm of total length are 0.571, 0.570.

Family SYNGNATHIDAE

The first Tasmanian catalogue, that of Johnston (1883), contained 8 species of syngnathids (including *Stigmatophora gracilis* Macleay, 1881, a synonym of *S. argus* Kaup, 1853), his second list (1891) adding *Syngnathus curtirostris* Castelnau, 1872. Later local lists, those of Lord (1923, 1927) and Lord and Scott (1924), included 12 species. However, only 7 species were credited to this State in the Check-List (McCulloch 1929) while the Handbook (Munro 1958) admits 15. The total now known from our waters amounts to 22 species: as the records of additions are scattered through several periodicals, Australian and extralimital — contributions in this series and in other journals by Scott (1942a 1968) and Dawson (1977) — it may be useful to enumerate them here. (i) *Leptonotus semistriatus* Kaup, 1856 (ii) *Sygnathus curtirostris* Castelnau, 1872 (iii) *S. phillipi* Lucas, 1891 (iv) *S. poecilolaemus* Peters, 1869, (v) *S. tuckeri* Scott, 1942 (vi) *S. mollisoni* Scott, 1955 (vii) *S. caretta* Klunzinger, 1879 (viii) *Lissocampus caudalis* Waite & Hale, 1921 (ix) *Urocampus carinirostris* Castelnau, 1872 (x) *Leptoichthys fistularius* Kaup, (xi) *Histiogamphelus briggsii* McCulloch, 1914 (vii) *Stigmatophora argus* (Richardson, 1840) (xiii) *S. nigra* Kaup, 1853 (xiv) *Ichthyocampus runa* (Whitley, 1931) (xv) *Solengnathus spinosissimus* Günther, 1870) (xvi)

S. fasciatus (Günther, 1880) (xvii) *S. robustus* McCulloch, 1911 (xviii) *Phyllopteryx taeniolatus* (Lacépède, 1804) — in Check-List as *Phyllopteryx foliatus* (Shaw, 1804) — (xix) *H. breviceps* Peters, 1870 (xx) *H. novaehollandiae* Steindachner, 1966 (xxi) *H. whitei* Bleeker, 1855 (xxii) *H. abdominalis* Lesson, 1827.

The 17 species then on the local list were keyed in Part X (1961) and a conspectus was provided giving synoptic values gathered from available literature of the known ranges for five meristic and four morphometric variates together with a specification of the rostral crest an indication of the presence or absence of an opercular keel and a note of the maximum recorded length. Extensions for several species of the ranges there set out have from time to time been noted in later contributions in this series.

Genus *HISTIOGAMPHELUS* McCulloch, 1914

Histiogamphelus McCulloch, 1914, *Aust. Zool.* 1(1), p.30. Type-species, *Histiogamphelus briggsii* McCulloch.

Histiogamphelus briggsii McCulloch, 1914

Histiogamphelus briggsii McCulloch, 1914, *Aust. Zool.*, 1(1), p.30, fig.4. Type locality: Thouin or Wineglass Bay, Tasmania.

Histiogamphelus briggsii McCulloch, 1929, *Aust. Mus. Mem.*, 5(1), p.92; Scott, 1968, *Tasm. Fisher. Res.*, 2(2), p.6: Whitley, 1964, *Proc. Linn. Soc. N.S.W.*, 89(1), p.38.: Whitley & Allan, 1958,SEA HORSE AND ITS RELATIVES, p.60, fig.16, 3.

Histiogamphelus briggsi: Lord, 1923, *Pap. Proc. R.Soc. Tasm.*(1921), p.13, and *J. Pan-Pac. res. Inst.* 2(4), p.13: Lord & Scott, 1924, SYNOP. VERT. ANIM. TASM., pp.8 40.

Histiogamphelus briggsii briggsii: Munro, 1958, HANDBK FISH. AUST., 21, p.85, fig. 590: Scott, 1961, *Pap. Proc. R.Soc. Tasm.*, 95, p.59.

Histiogamphelus briggsii orae Whitley, 1950, *Rec. Aust. Mus.* 22(3), p.238. Type locality: Thompsons Bay, Coogee, near Sydney, New South Wales.

Histiogamphelus briggsii orae: Munro, 1958, HANDBK FISH. AUST., 21, p.85: Whitley, 1964, *Proc. Linn. Soc. N.S.W.*, 89(1), p.38.: Whitley & Allan, 1958, SEA-HORSE AND ITS RELATIVES, p.60.

Material

A specimen, *Ls* 180 *Lt* 186, dredged in 15 fathoms (17 m) 9 miles (14 km) north-west of Binalong Bay, east coast, in July 1979 by Mr Shane Down (Q.V.M. Reg. No. 1979/5/111).

This specimen exhibits some features stated to be characteristic of *Histiogamphelus briggsii briggsii* some stated to be characteristic of *Histiogamphelus briggsii orae* and some not in agreement with the descriptions of either. After some consideration it is here referred to *H. briggsii* without subspecific specification, its taxonomic status being discussed below.

Meristic characters

Of the entries in parentheses the first in each case is that reported by McCulloch (1914) for his *Histiogamphelus briggsii* from Tasmania the second that reported by Whitley (1950) for his *Histiogamphelus briggsii orae* from New South Wales. Annuli 22 + 39 (22 + 36, 21 + 35). Subdorsal annuli 5 + 3 (5 + 2, 6 + 2). Brood annuli 1-14, at 0.7 0.2 of annulus respectively. D. 25 (23, 25). P. 14/14 (13, 12). C. 6 (from figure 10 —). A. 3? (no data).

Dimensions

The following dimensions are given as millesimals of length to base of caudal (*Ls* 180) with length in mm in parentheses. Total length 1 033(186). Head 108(19.5). Snout 53(9.5). Eye 19(3.4). Interorbital 9.4(1.7). Length of operculum 46(8.2) width 23(4.1). Length to pectoral origin 111(20.0) length of fin 17(3.0) base

measured obliquely 14(2.5). Length to dorsal origin 358(64.5) to termination 449(80.9). Length of caudal 33(6.0). Length to vent 403(72.5). Length to origin of brood pouch 419(75.5) to termination 613(110.3). Depth at middle of snout 4.8(27) front of eye 23 (4.1) back of eye 26(4.6) middle of operculum 30(5.4) hind border of operculum 29(5.2) vent 22(4.0) base of caudal 6.7, maximum depth of head 30(5.4) of trunk 30(5.4). Width at same seven points 8.9(1.6) 15(2.7) 20(3.6) 28(5.1) 22(4.0) 19(3.5) 7.2(1.3), maximum width of head 28(5.1) of trunk 22(4.0).

Proportions

Where available proportions given by McCulloch and Whitley or calculable from their recorded dimensions are shown in parentheses (former first). The set of proportions reported in specific diagnoses of syngnathids shows some variation with authors (e.g., head in trunk or in length to vent or in standard length): most variants in frequent use are here noted.

Head in trunk 2.72(3.6 2.82) in length to vent 3.72 (4.6 3.8) in standard length 9.23 in total length 9.54 (— 8.82). Trunk in tail without caudal 2.03 in tail with caudal 2.14 (— 1.77) in total length 3.51 (— 3.13). Head and trunk together in tail without caudal 1.48 with caudal 1.57 ('tail' 1.3 tail with caudal 1.31). Snout in head 2.05 (2.1 2.2). Eye in snout 2.79 (2.5 1.7). Interorbital in eye 2.00. Length to dorsal origin in standard length 2.79 length to termination in standard length 2.22 base of fin 11.0 in standard length or 3.93 (from figure about 4.6 —) in length to its origin. Pectoral length in head 6.50 (from figure about 6 —) base in head 7.8. Caudal length in head 3.25 (3 'nearly 3'). Maximum depth of head in head 3.61 (from figure about 3.4 —) in standard length 33.3, maximum depth of trunk in head 3.61 (from figure about 2.2 —) in standard length 33.3. Length of brood pouch region in tail 3.07 in standard length 5.18.

Description

Smooth, without cutaneous appendages. Trunk and tail subquadrangular, depth of trunk almost uniform that of tail decreasing evenly, at termination one-third that at origin, depth of trunk 1.3 of tail 1.2 its greatest width, former 3.8 in head.

Body ridges are here denoted by a two-letter system thus: first letter either T = trunk or C = caudal, second letter one of these S = superior (superolateral) D = dorsal (here and normally medial) V = ventral (here and normally medial) L = lateral (if as here single then more or less medial) — for a discussion of notation including a comparison of this with other systems see Part XXIII (1977, p.125).

TS well developed, exhibiting a somewhat unusual feature in being disjunct with a brief hiatus at the end of each annulus the interval usually including a minute rounded boss, terminating below dorsal fin at 0.8 of second dorsal annulus slightly (left) decidedly (right) closer to dorsal profile than to CS, which is similarly disjunct in some anterior annuli and which leaves dorsal profile at hind border of third caudal annulus (at level of dorsal fin termination) swinging down to end at 0.2-0.4 of penultimate trunk annulus, being there equidistant from TL and TS. TL similar in structure to TS, ending at 0.9 of penultimate trunk annulus, hence overlapped by CS for most of one annulus, tip a trifle closer to ventral than to dorsal profile, not turned down. TL continuous with CL both showing very brief interruptions at annulus junctions. TV subcontinuous and in general similar in structure to TS but with some ridge sections presenting noticeable terminal dilatation, stronger than other trunk ridges. Ventral surface of tail shows some measure of collapse being deepest mesially, no clear evidence of the existence of CV. Each plate with a doubly lyrate pattern of striae suggestive of the conventional karyokinetic spindle.

Head rather long stout. Snout stout its length subequal to that of rest of head.

The conspicuous thin elevated rostral ridge begins at upper lip and rises rapidly strongly convexly to attain its maximum height (2 mm or about two-fifths total height of snout) near the first one-fifth of its length, thereafter running back, as far as can be determined (margin damaged for about 1 mm near middle of length) virtually horizontally, to level of front of eye beyond which it curves down increasingly rapidly though overall rather slowly to end 0.2 mm above supraorbital ridge just behind level of second one-third of orbit. Though the upper border of the ridge is briefly interrupted a tolerably reliable reconstruction would seem to make clear the absence from here of any such notch in the profile as is a diagnostic feature of e.g., subspecies of *H. maculatus* Hale, 1939. Though McCulloch expressly states 'the upper margin of the ridge is entire' his figure would seem to indicate the presence of a minute notch separating the rapidly ascending anterior portion from the subhorizontal section following it (this feature not necessarily recognizable in reproductions of the original illustration). Such a nick is present in our fish, its location being emphasized first by the existence of a dark slightly proconvex line running down and slightly back from it, and secondly by the fact that immediately behind it there is a compact series of striae, about a score in the intact region, running down and back towards base of ridge, the anterior stria, with its tip at the notch, at an angle of about 45° those behind it progressively more nearly upright the hindmost close to vertical, while in advance of the notch there are indications of a separate fan of striae the general sense of which is subvertical. There is thus some suggestion the rostral crest may represent the fusion of (at least) two plates. The whole external border is defined by a very slender ridge seen under a lens to be minutely denticulate.

Other cephalic ridges include: (a) a median one on dorsum in line with the rostral crest but separated from it by about one-third of an eye diameter extending back, rather feebly posteriorly, over occiput and nape to above middle of pectoral base behind the origin of TS (b) one defining upper border of the tubular snout terminating at middle of anterior border of orbit (c) one defining lower border of snout continuing, slightly below eye, almost to level of back of orbit (d) one immediately above eye its middle half part of orbital rim (well elevated throughout) its length subequal to an eye diameter, the pair viewed from above convex outward, a little wider apart at their posterior than at their anterior ends (e) on ventral surface two median ridges originating near tip of lip, very shortly approximating then diverging to a small maximum about at level of the nick in the rostral crest, thereafter running back subparallel for most of their length to diverge strongly below eye.

Eye rather large equidistant from dorsal and ventral profiles. Nostrils close together encircled by a common low rim shortly in advance of upper half of eye, anterior obliquely below posterior, feebly tubular. Operculum with many fine radiating striae and anteriorly a well developed keel lapsing to extinction in last one-third of length.

Dorsal with 25 simple rays on an elevated base covering five trunk and three tail rings. Pectoral with 13 simple rays, base strongly elevated obliquely down and back, proconvex. Caudal rounded apparently with 6 stout rays. Anal minute probably with 3 rays. Though no functional brood pouch is developed its location is clearly indicated by two folds of moderate height, originating on first caudal annulus diverging over less than the length of an annulus and continuing back parallel to end on fourteenth annulus, the interval between them a little greater than half total ventral width. It is not certain whether the pouch has regressed or is incipient; the coloration (see below) would suggest the former as more likely — some data on seasons of brood pouch development in various Tasmanian species are collected in Part XVIII (1970, p.123) and Part XXIII (1977, p.133). The presence in this specimen of the folds of a brood pouch immediately behind the vent at length substantiates for this species and it may reasonably be assumed for this genus the general 'Brood pouch (males) presumably

subcaudal' of the Handbook.

Coloration

Lateral surface of trunk pale fawn, an obscurely delimited patch of whitish on each annulus, anteriorly near middle posteriorly adjacent to TI and less extensive; ground color continuing on to tail but there progressively deepening caudad to mid fawn. Dorsal surfaces of trunk and tail much similar to lateral, trunk without whitish markings but most anterior annuli of tail with an inconspicuous lightish spot at middle of annulus junction. Whole lateral surface of trunk and of first half dozen annuli of tail with small circles spots or annuli, now inconspicuous but possibly more evident in life, now dark brown but reported to have shown some bluish earlier, 7-10 on anterior annuli there smallest, 1-2 on posterior, most annuli in last three-quarters of trunk with one largish faintly annulated spot regularly developed near middle shortly above TL. Ventral surface of trunk basically light fawn a little lighter than lateral surface, each annulus with on either side an inconspicuous whitish spot often surrounded by some diffuse whitish. Whole brood pouch region including strips of ventral surface externad of the ridges at once identifiable by its dark brown in sharp contrast to the very much lighter trunk and the noticeably lighter portion of tail behind it; section of transverse interannular ridges outside folds whitish, between folds with a whitish spot or diffuse patch at their middle, folds blackish in front lightening somewhat behind. Head similar overall to trunk, upper anterior portion of rostral crest reddish brown, rest brownish except fine ridge constituting its distal border which is blackish, some touches of silvery on operculum particularly below. Pectoral rays concolorous with or a trifle lighter than trunk nearby. Dorsal rays pale straw, a small dark proximal smudge near front of fin. Caudal rays dusky gold throughout, membrane blackish.

Head, length to vent, standard length.

These lengths are satisfactorily specified both for the present specimen (t 541.237**) and for the holotype of *H. briggsii orae* (t 39.270*) by the subjoined equations in which N has successive values of 1 5 10.

Log L = 0.9757 log N + 1.2771; measured (predicted) lengths 19.5 (18.9) 72.5 (73.2) 180 (179).

Log L = 0.9345 log N + 1.0469; 11 (11) 42 (41) 94 (96).

Discussion

As already observed the present specimen exhibits some features noted as characteristic of *Histiogamphelus briggsii briggsii* in contrast to those of the other subspecies, some stated to be diagnostic for *H. briggsii orae* and some not in accord with the description of either.

It is first to be noted that the descriptions of McCulloch and Whitley are in each case based on a single individual and the relevant entries in the Handbook (Munro 1958), species 590 591, merely repeat the original data without indication of a possible range of quantitative (or qualitative) items. Further, compounding the problem thus presented, an absence of such ranges characterizes the Handbook diagnoses of all other species of the genus *Histiogamphelus* there recognized, namely 592 *H. meraculus* Whitley, 1948, 593 *H. cristatus* (Macleay, 1882), 594 *H. maculatus maculatus* Hale, 1939, 595 *H. maculatus robensis* Whitley, 1948, 596 *H. gallinaceus* Hale, 1941, the first two from Western Australia, the remaining three from South Australia. We are thus left without any information on the extent of individual variation within the genus, a circumstance that precludes a definitive judgement of the systematic status of the present specimen.

Our fish may be briefly compared with the published accounts of *H. briggsii briggsii* and *H. briggsii orae* in respect of the more important features. Caudal annuli: at 39

more numerous than in either and indeed than in any other species of this genus (27-36; note a variation, 33 36, in subspecies 594 595). Subdorsal annuli: one more than in *H. b. briggsii* disposed differently from *H. b. orae* (note one more subcaudal in subspecies 594 595). Dorsal rays: one more than in *H. b. briggsii* same number as in *H. b. orae*. Pectoral rays: one more than in *H. b. briggsii* two more than in *orae* (in subspecies 594 595 12 14). Caudal rays: 6, from figure of *H. b. briggsii* 10. Form of trunk: strikingly different from *H. b. briggsii* as figured, increasing noticeably in depth caudad to a maximum of about 2.2 in head, while in our specimen trunk is of virtually uniform depth throughout with a maximum of 3.61 in head; no data for *H. b. orae* — McCulloch's specimen is a female (as apparently also is Whitley's), raising the possibility that here (as in, e.g., *Leptonotus* Kaup, 1853) the marked difference in body depth may be a sex character (our specimen a male); no information of any possible sex dimorphism in the other species of *Histiogamphelus* recognized in the Handbook, all accounts of which are based on females, each entry including the notation 'Brood pouch (males) presumably subcaudal'. Opercular keel: no keel in *H. b. briggsii*, in *H. b. orae* 'a short keel anteriorly' as in our specimen. Coloration: *H. b. briggsii* 'with numerous dark edged, blue ocelli', *H. b. orae* 'without blue spots, but with some smudged small dark brown spots', our specimen with numerous spots, some annulated, probably originally blue or bluish, covering whole of trunk but confined to anterior portion of tail as figured for *H. b. briggsii*. Rostral ridge: in our fish in excellent agreement with illustration of *H. b. briggsii* — the form of this crest would appear to be the most important single qualitative character in species of this genus.

In the absence of data on possible intraspecific variation in *Histiogamphelus* the status of the present specimen is not definitely determinable. However, after review of all the available evidence, with very considerable weight given to the known and probable nature of the color pattern, it is suggested it may be expediently determined as *Histiogamphelus briggsii*. Further, as this fish exhibits some features characterizing each of the two described subspecies and in some other features lies between then it is suggested these subspecies be abandoned, all presently known material being ascribed to *Histiogamphelus briggsii* McCulloch, 1914.

Family KYPHOSIDAE

The family Kyphosidae in the broad sense adopted by Greenwood *et al.* (1966) in their provisional classification of living teleosts includes nine Tasmanian respresentatives commonly distributed in Australian texts among three spearate families, Kyphosidae *sensu stricto* (3 local species) Scorpidae (sometimes rendered Scorpididae) (3) and Girellidae (3). The fish noticed below, *Girella tricuspidata* (Quoy & Gaimard, 1824) enters Girellidae, a key to the Tasmanian representatives of which is given in Part XI (1963, p.22).

Genus *GIRELLA* Gray, 1835

Girella Gray, 1835, ILLUSTR. INDIAN ZOOL., 2(19,20), pl.98, fig.3. Type-species, *Girella punctata* Gray.

Girella tricuspidata (Quoy & Gaimard, 1824)

Boops tricuspidatus Quoy & Gaimard, 1824, VOY. URANIE PHYSIC. ZOOL., p.296.
Type locality: 'Shark Bay', Western Australia.
Melanichthys tricuspidata: Castelnau, 1872, *Proc. zool. acclim. Soc. Vict.*, 1, p.67.
Girella tricuspidata: McCulloch, 1929, *Aust. Mus. Mem.*, 5(2), p.239 (references and synonymy).

Xanthic individual

The generally dark overall color of this species suggested to Temminck & Schlegel (1850) the descriptive generic name *Melanichthys* (not recognized by Günther (1859) nor

noted in the generic synonymy in the Check-List (McCulloch 1929), but adopted after some consideration by Castelnau (1872). The fish goes under a variety of vernacular designations, most bearing reference to its normally sombre appearance. In all local lists it is called black bream (a name in use also in New South Wales and Queensland); other names include nigger (New South Wales), blackfish (Queensland, New South Wales, South Australia), darkie (New South Wales), luderick (New South Wales, Victoria, South Australia; the official commercial name), black perch (Victoria). Marshall (1964, p.175) gave the Tasmanian vernacular name as cocky salmon; however this appears to be applied in this state chiefly if not exclusively to *Arripis trutta esper* Whitley, 1951, family Arripidae (also known as black-back or Australian colonial or cocky salmon).

A xanthic example of this species, *Ls* 261 *Lt* 326, caught off the wharf at Stanley, northwest coast, in January 1979 by Mr J. Eales (Q.V.M. Reg. No. 1979/5/5) presented a sight at once curious and beautiful. Apart from the eye (pupil dark blue iris very pale orange with an obscure peripheral dusky annulus) the whole specimen was bright canary yellow. A striking feature was the uniform and pervasive nature of the coloration, fin spines fin rays and fin membranes being indistinguishable from the rest of the fish. The normal coloration is 'brownish above, lighter below with about 12 narrow, vertical dark bands on the back and sides, becoming indistinct on the lower parts' (Scott 1962, p.204). In some individuals the dorsal surface comes close to black and the ground color of the flank is at times greyish rather than brownish: the dark bars of which there may be as few as 4 or 5 — noticeably narrower than those of the rather similar *Melambaphes zebra* (Richardson, 1846) — usually become lost after death. Marshall (1964, p.175) noted 'a pale canary-yellow tinge on cheek, lips and throat' and Castelnau (1872, p.67) mentioned a yellowish tinge on 'the anterior part of the head, and even on the operculum': however such yellowishness is not always evident in Tasmanian examples.

After having been in a formalin fixing tank for a couple of weeks the fish exhibited considerable fading, being in large part pale yellow or whitish, the loss of the original color least marked on the upper part of the head and body, basally on the fins.

Remarks

In general xanthochroism is rare among fishes though it is well known among some freshwater forms. Thus the tench, *Tinca tinca* (Linné, 1758), occasionally changes from its normal dull greyish color to a bright orange yellow, while the golden carp or common goldfish, *Carassius auratus* (Linné, 1758), a native of China and Japan that has now been introduced into all Australian States, changes, particularly under the influence of domestication, from its original dull brown or greenish, becoming in its first year melanistic later silvery and finally reddish gold (exceptional individuals exhibiting albinism). In a subject index prepared as an appendix to a presidential address to the Linnean Society of New South Wales Whitley (1964, p.22) listed under *Xanthism* three references relating to eels, Anon (1956), Kershaw (1904), both localities Victoria, Scott (1942a) Tasmania; citing also without comment Haysom (1960) and Whitley (1952). In the last-mentioned paper Whitley stated that the Australian Museum, Sydney has two xanthic fish both belonging to the present species, one 'canary-yellow almost all over, except for a few scattered blotches or spots of dark grey' the other ' almost entirely canary-yellow', both caught at Malabar near Sydney in 1951, the first in February the second in August. In a passage that appears to have been overlooked in this context Castelnau (1872, p.67) observed 'In the warm months, the color of this fish seems to become much lighter; and in December, I have seen many specimens almost white'.

In his 1964 account Whitley noted a third xanthic fish in the Australian Museum collection, also a kyphosid, there cited as *Segutilum sydneyanum*, but referred to in almost all Australian texts as *Kyphosis sydneyanus* (Günther, 1886), the genus *Segutilum* Whitley, 1931, though maintained by its author in his latest list (1964), not having

received general local recognition. It is certainly a matter of some general interest that members of the family Kyphosidae represent so high a proportion of the few available records of xanthochroism in Australian fishes.

Dimensions as *TLs*

Length to origin termination of first dorsal 314 670, second dorsal 690 854, anal 617 900. Length to origin total length of pectoral 230 211, of ventral 280 180. Length to vent 571. Head 241. Snout 80. Eye 64. Interorbital 65, internarial 57. Longest ray of dorsal 110 anal 137 pectoral 172 ventral 172. Longest spine of dorsal 107 anal 100. Depth at operculum 149 at vent 130, maximum depth 161, depth of caudal peduncle 134.

Aspects of form

(a) *Head, length to vent, standard length.* On a loglog grid these three lengths are significantly linear (t 34.823*) on 1 2 3.

Log L = 1.2881 log N + 2.3790. Predicted lengths 239(241) 584(571) 1 000.

(b) *Disposition of fin origins and terminations.* In a loglog plot length to origin of first dorsal origin of anal origin of second dorsal termination of second dorsal termination of anal and origin of caudal (*Ls*) are highly significant (t 58.002***) on 2 5 6 8 9 10.

Log L = 0.7116 log N + 2.2856. Predicted lengths 316 607 691 848 922 991 (measured lengths above).

(c) *Anal spines.* As with many species in divers groups the logarithmic lengths of spines 1 2 3 are collinear on logarithms 1 2 3.

Log L = 0.6278 log N + 1.1199; t 24.387*; measured (predicted) lengths, mm, 13.1(13.2) 20.7(20.4) 26.0(26.2).

(d) *Ventral rays.* In a pattern frequently encountered the logarithmic lengths of the four rays postaxial to the spine taken in order of ascending magnitude (starting from outermost) represent a linear function of their serial numbers.

Log L = 0.2622 log N + 1.4857; t 6.869*; measured (predicted) lengths, mm, 31.3 (30.6) 35.0(36.7) 41.0(40.8) 44.9(44.0).

Family SOLEIDAE

Genus *ZEBRIAS* Jordan & Snyder, 1890

Zebrias fasciatus (Macleay, 1882)

Synaptura fasciata Macleay, 1882, *Proc. Linn. Soc. N.S.W.*, 7(1), p.14. Type locality: Port Jackson.

Synaptura fasciata: Waite, 1899, *Mem. Aust. Mus.*, 4(1), p.126, pl.31: McCulloch, 1911, *Mem. Qld Mus.*, 5, p.61, pl.8, fig.2: McCulloch, 1929, *Mem. Aust. Mus.*, 5(2), p.285.

Brachirus fasciatus: Norman, 1926, *Biol. res. Endeavour*, 5(5), p.295.

Zebrias fasciatus: Munro, 1957, HANDBK AUST. FISH., 17, p.71, fig.494.

Tasmanian status of species

No member of the family of dextral or true soles, Soleidae, is noted in any published local catalogue, nor is any credited to Tasmania in either the Check-List (McCulloch 1929) or the Handbook (Munro 1957b), the first record of the present species in our water being given in Part XXI (1975), based on two examples, one, *Ls* 131, collected between East Sandy Cape and Thirty Day Island, one, *Ls* 96, obtained off Prime Seal Island, Furneaux Group, Bass Strait. A third example, *Ls* 140 (Q.V.M. Reg. No. 1975/5/156), taken off St Helens, east coast, was reported without descriptive data in

Part XXII (1976), together with two smaller soles in a poor state of preservation, probably referable to this species. *Zebrias fasciatus* had previously been known only from New South Wales and Queensland. An additional, larger example, *Ls* 158 *Lt* 174, dredged by Mr Shane Down off Eddystone Point, east coast, in 25 fathoms (46 m) in June 1979 (Q.V.M. Reg. No. 1979/5/67) is here noticed.

Meristic characters

D. 85. A. 71. V. 4/4. P. 6/6. These counts all fall within recognized ranges (Waite 1899, McCulloch 1916, Munro 1957b); the larger of the two individuals described in Part XXI had an exceptionally low number of anal rays, 58.

Dimensions and proportions

Head (27.5 mm) 5.7 in *Ls* or 6.3 in *Lt*. Depth at front of eyes (25) 6.3, at back of eyes (38) 4.2, at operculum (50) 3.2, maximum depth (53) occurring at about anterior one-third of length of fish 3.0, chord of arc of base of caudal rays (11) 14.4, all proportions in *Ls*.

Upper eye eyeball only (5.0) 5.5 including soft orbit (6.7) 4.2, lower eye eyeball only (4.1) 6.7 including soft orbit (6.0) 4.6, interorbital betweeen eyeballs (4.6) 6.0 between inner edges of orbits (1.9) 14.5 snout to level of front eyeball (6.5) 4.2, shortest distance (callipers) between upper eyeball and dorsal profile (3.9) 7.1, shortest distance between lower eyeball and ventral profile (5.1) 5.4, length of maxilla (6.9) 4.0, length of lower jaw (13.9) 2.0, all proportions in head.

First dorsal ray (2.1) 13.1 ray at middle of fin (16.4) 1.7 last ray (14.8) 1.9, first anal ray (6.6) 4.2 ray at middle of fin (13.5) 2.0 last ray (11.0) 2.5, median caudal ray (21.3) 1.3, longest ventral ray of ocular side (6.5) 4.2 base of that fin (5.0) 5.5, longest ventral ray of blind side (7.0) 3.9 base of that fin (7.3) 3.8, length of pectoral of ocular side (4.0) 6.9 transverse extent of that fin (4.0) 6.9, length of pectoral of blind side (3.4) 8.1 transverse extent of that fin (5.0) 5.5, all proportions in head.

While in this set of proportions, which is essentially that adopted by Norman (1934) in his memoir on the flatfishes, there are not unexpectedly some differences from the values noted in Part XXI for the two Tasmanian examples there considered, no noteworthy variations are apparent. The present fish, the largest of the three, is closer to the larger of the earlier specimens in more than two-thirds of the ratios.

Coloration

This shows some differences from that of the two examples reported upon earlier. Ocular side virtually uniform slate (*cf.* brownish), light brown where scales are missing; about two dozen dark cross bars of which four are on head, subvertical or slightly pro-convex, mostly somewhat narrower than their interspaces. Blind side mainly cream, differing markedly from the uniform whitish of the earlier examples in having a conspicuous well-delimited band of pinkish about 5 mm in width situated immediately internad of the dorsal and anal bases and extending continuously from just behind head to caudal base. Light borders to dorsal and anal narrow, much as shown by Waite (1899, pl.31) less extensive than as shown by McCulloch (1916, pl.8, fig.2), whose illustration was selected for reproduction in the Handbook (Munro 1957b). Right ventral very faintly dusky, first ray almost wholly white, left white. Right pectoral off-white touched with pale slate, left wholly white.

Remarks

Bases of the small pectorals relatively very wide, the connexion with the branchiostegal membrane somewhat less funnel-like on the ocular side, here approximating the condition that led Weber & de Beaufort (1929, p.167) to reject *Zebrias* Jordan

& Snyder, 1901 and adopt *Synaptura* Cantor, 1849 (*nom. nov. pro. Brachirus* Swainson, 1839, considered to be preoccupied by *Brachyurus* Swainson, 1839, another genus of fishes). As in our other examples of which descriptions were provided the caudal has somewhat more the appearance of a separate structure and is rather more pointed than as depicted by McCulloch, more nearly approximating its appearance in the illustration of the *Thetis* specimen by Waite. Save for a subcircular area on operculum whole of lower surface of head thickly beset with slender tapering white cirri, most abundant and largest along ventral border where their length may exceed half total eye, one or two series fringing hind margin of operculum most of these somewhat stouter than elsewhere. In this individual the cirri extend beyond the head, briefly bordering the upper half of the operculum and, exceptionally, occurring on the trunk in an elongate triangle defined below by a line sloping back and up from upper end of operculum to dorsal profile and above by the profile, total length of this pennon about twice that of head.

Family ODACIDAE

Following the establishment by Castelnau (1875) of the genus *Neoodax* the group of shallow-water mostly small and commercially unimportant fishes vernacularly known as rock whitings or reedy whitings has generally been treated locally as the family Neoodacidae (variant, Neoodaciidae). However, the earlier Odacidae was retained in the Check-List (McCulloch 1929) and this is the designation recommended by Greenwood *et al.* (1966) in their provisional teleost classification (as recognized by them it includes Siphonognathidae, usually treated in Australian texts as distinct.)

Four species are credited to Tasmania among the Odacidae in the Check-List — (a) *Olisthops cyanomelas* Richardson, 1850 (appears in the second local catalogue of Johnston (1891) as the synonymic *Olistherops brownii* Johnston, 1884 — *Olistherops* Günther, 1862 a synonym of *Olisthops* Richardson, 1840 — and the synonymic *Odax richardsonii* Gunther, 1862, second binomen rendered *Richardsoni* by Johnston) (b) *Neoodax semifasciatus* (Valenciennes, 1839) (now usually referred to *Haletta* Whitley, 1947) (c) *N. balteatus* (Valenciennes, 1839) (the synonymic *Odax algensis* Richardson, 1840 has Port Arthur, Tasmania as type locality) (d) *N. attenuatus* (Ogilby, 1897) — together with one species (e) *Odax beddomei* Johnston, 1885, relegated in the Check-List to Siphonognathidae (genus *Siphonognathus* Richardson, 1858). In Part XII (1964) (f) *N. radiatus* Quoy & Gaimard, 1835) (type species of *Sheardichthys* Whitley, 1947) was added to the Tasmanian list, a key covering (a) (b) (c) (d) (f) being provided, and in Part XIV (1966) (g) *N. frenatus* was reported from our waters (though accepted as a valid species in the Check-List, *N. frenatus* is stated by J.K. Scott (1976) to be merely the female of *N. radiatus*). In Part XVI (1969) it was shown that the transference in the Check-List of (e) to Siphonognathidae — an action suggested by the publication by Whitley (1929a) of a sketch included among the R.M. Johnston memoranda that appears to show that the ventrals, of which no express mention occurs in the description (1885) were lacking (a siphonognathid feature) — was in error, the ventrals being present, though readily overlooked when adpressed, in a fish dredged between Flinders and Cape Barren Islands, Bass Strait that was in all other respects in satisfactory agreement with Johnston's account of his *Odax beddomei* from the River Derwent. A specimen of (d) *N. attenuatus* (Ogilby, 1897), a species that had been wholly lost sight of since its description, was described and figured in Part XIX (1974a), which also provided a key covering all seven local species.

Genus *NEOODAX* Castelnau, 1875

Neoodax Castelnau, 1875, VICT. OFFIC. REC. PHILAD. EXHIB., p.37. Type-species, *Neoodax waterhousii* Castelnau, 1875 = *Odax balteatus* Valenciennes, 1839.

Haletta Whitley, 1847, *Aust. Zool.*, 11(2), p.146. Type-species, *Odax semifasciatus* Valenciennes, 1839.

Sheardichthys Whitley, 1947, *Aust. Zool.*, 11(2), p.146. Type-species, *Malacanthus radiatus* Quoy & Gaimard, 1835.

Neoodax attenuatus (Ogilby, 1897)

Odax attenuatus Ogilby, 1897, *Proc. Linn. Soc. N.S.W.*, 22(1), p.83. Type locality: Tasmania.

Neoodax attenuatus: Scott (E.O.G.) 1974, *Pap. Proc. R. Soc. Tasm.*, 107, p.280, fig.2: Scott (J.K.), 1976, *Rec. W. Aust. Mus.*, 4(4), p.357.

History of species

Described after the publication of Johnston's second catalogue (1891), this species did not find its way into any subsequent local list, apparently being simply overlooked by Lord (1923 1927) and by Lord & Scott (1924). Ogilby (1897a, p.84) stated of his single specimen, *Ls* 95, 'Type in the Tasmanian Museum, Hobart' and this statement appears in the Check-List. However, as noted above, Lord, at the time of compilation of his two lists Director of the Museum, failed to take cognizance of this species; moreover it is not included in the list by Andrews (1971) of the fish type material in that institution: the holotype may be presumed lost.

Neoodax attenuatus has been keyed in Parts XII XIX (1964 1974a) also by J.K. Scott (1976). It may be identified at sight by its agreeing with *N. beddomei* and differing from all other species in having depth more than 9 (about 9.5-11.0) in *Ls* instead of less than 8 (about 4.5-7.0) and in possessing a black marking on the caudal fin; but differing trenchantly from *N. beddomei* in its much shorter snout, subequal to eye and 3-4 in head as against 3-4 times eye and 2 or less in head, and in having the anal fin ending before dorsal by an interval subequal to its base instead of ending about below the penultimate dorsal ray.

In Part XIX (1974a, p.280, fig.2) an odacid, *Ls* 75, dredged in 30 m at Primrose Bay, east coast, on 13 October 1970 by Mr D.C. Wolfe, who recognized its unusual character, was described and figured as an example of Ogilby's long-missing *Odax attenuatus*. Two specimens, *Ls* 47 69, from Geographe Bay, Western Australia, were reported by J.K. Scott (1976, p.357) in a review of the Odacidae of that State; his paper includes a description of a new genus *Parodax* in which supplementary canines are associated with the normal fused teeth of the upper and lower jaws.

Material

Three specimens, (a) *Ls* 94.0 *Lt* 117.2, dredged in 25 fathoms (46 m) off Eddystone Point, east coast, 22 June 1979 (Q.V.M. Reg. No. 1979/5/74) (b) *Ls* 94.0 *Lt* 117.2 (c) *Ls* 100.0 *Lt* 128.5, both dredged in 15 fathoms (27 m) 9 miles (14 km) northnorthwest of Finalong Bay, east coast, 30 July 1979 (common Q.V.M. Reg. No. 1979/5/108), all collected by Mr Shane Down.

Meristic characters

D. XX,15; XX,13; XX,15. A. III, 8; III, 8; III,10. P. 13/13; 13/13; 14/14 V. 1, 4. C. main rays 14 14 14 (10 10 10 divided). Lateral line scales to level of hypural 43 46 44 plus 1-6 (number may differ on two sides of fish) extending on to caudal. L. tr. 4/6. Br. VI. One of the two Western Australian examples reported by J.K. Scott (1976) has only XIX dorsal spines. In both dorsal and anal spines are not noticeably more rigid than rays and as the septa in the latter may not always be readily observable and branching may be minimal and then with the short limbs closely apposed, distinction between spines and rays may present some difficulty; however, the latter are regularly somewhat stouter.

In the course of a comparison of the type of *N. attenuatus* and Johnston's account of his *N. beddomei* Ogilby observed (footnote, p.85), 'Mr. Johnston has recorded three

spinous rays as being present in the anal fin in his example, but a most careful examination under the microscope, both by Mr. Whitlegge and myself, has been unsuccessful in bringing to light more than a single spine in Mr. Morton's fish.' In the account of the Promise Bay example it was noted (1974a, p.283) there were two anal spines very closely approximated basally, the length of the first being about half that of the second. The same situation obtains in the present material but examination of these specimens would seem to indicate that the third element, earlier interpreted as a ray, is in fact a spine. From time to time in this series it has been noted that for a wide range of species in which three anal spines are present their logarithmic lengths are collinear on logs 1 2 3. Using mean spine lengths for the present specimen it is found such is the case here to a probability of better than P. 0.05 — an interesting instance of a systematic application of this formal relation. Three anal spines have been reported for Western Australian material.

Dimensions

Dimensions are given as millesimals of standard length with the present specimens cited in ascending order of *Ls* (94 100 110) followed in parentheses by the value for the Promise Bay specimen (*Ls* 75).

Total length 1 247, 1 285, 1 264 (1 229). Length to origin of first dorsal 233 243 241 (241) to termination (base of last spine) 553 606 591 (595). Length to origin of second dorsal (base of first ray) 565 627 607 (613) to termination (base of last ray) 777 840 814 (847). Length to origin of anal 638 676 649 (660) to termination (base of last ray) 739 794 745 (760). Pectoral, length to origin 201 216 219 (267) length of longest (8th) ray 132 132 120 (139) length of whole fin 154 149 137 (164). Ventral, length to origin 269 260 272 (267) length of longest ray 127 135 110 (92) length of whole fin 94 89 107 (105). Length to vent 622 656 627 (647). Length of first dorsal spine 48 41 63 (57) of second spine 65 65 73 (72) of last spine 65 70 72 73 (72) of last spine 65 70 72 (65). Length of first dorsal ray 65 70 72 (65) of seventh ray 76 80 103 (78) of last ray 64 61 64 (73). Length of first anal spine 29 21 28 (27) of second spine 49 45 54 (53) of third spine 77 77 71 (—). Length of first anal ray 88 80 80 (72) of third ray (about longest) 83 90 91 (80) of last ray 51 50 55 (40). Head with soft opercular lobe 223 223 227 (231) without lobe 204 202 209 (213). Snout 77 70 71 (67). Eye 56 51 49 (61). Orbit 71 60 56 (67). Interorbital, soft 36 47 50 (51) bony 32 43 46 (—). Depth at front of eye 52 70 55 (64) at back of eye 64 80 65 (80) at operculum 74 87 80 (83) at vent 85 91 87 (81), maximum depth 95 110 102 (93), depth of caudal peduncle 51 50 59 (53). Width at front of eye 49 51 55 (65) at back of eye 59 68 66 (65) at operculum 69 70 73 (80) at vent 43 49 55 (45), maximum width 75 80 82 (80), width of caudal peduncle at caudal base 11 13 16 (13).

Proportions

The overall range for the present specimens together with the Promise Bay individual is followed, where the variates are available, by the range (2 specimens) reported (J.K. Scott 1976) for Western Australian material.

Head 4.34-4.52 3.9-4.3 trunk 2.30-2.51 tail (without caudal) 2.65-2.92 greatest depth 9.09-13.2 9.9-10.8 dorsal base 1.65-1.84 1.7-1.8 all in standard length. Length of pectoral 1.41-1.66 2.0-2.7 length of ventral 2.12-2.48 2.8-3.5 base of anal 2.21-2.36 1.7-24 snout 2.92-3.46 eye 3.76-4.63 orbit 3.13-4.03 all in head. Eye in snout 1.09-1.44 0.8-1.1 Interorbital soft 0.98-1.56 bony 1.06-1.77 in eye. Interorbital soft 1.32-3.11 bony 1.53-2.40 in snout — without specification of interorbital 1.0-1.1. The lesser value for pectoral and ventral lengths relative to head length reported from Western Australia may be attributable to differences in measurement procedures, our convention for the paired fins (origin taken as anterior border of fin root) being such as to yield a maximum length. When the Western Australian figures are compared with our values for length of longest ray the ranges overlap, ours being 1.66-2.03 for

pectoral 2.50-2.99 ventral.

Coloration

J.K. Scott (1976) has the following note on coloration, 'The basic color of fresh specimens is red-brown with a prominent black spot on the caudal fin'. Both the individual described in Part XIX (1974a) and specimen (a) of the present series had suffered considerable decolorization as a result of preservation. However, while (b) and (c), examined after two days in alcohol, had already tinged the fluid pale orange, they retained sufficient of the original coloration to provide some useful information. A summary of notes then made follows.

Overall rather sharply bicolor, on dorsum and on side above the midlateral line trunk and tail warm brownish tinged with pinkish, below pale orange. In upper region scales abundantly peppered with dark brown, the punctulation more intense near the hind border thus providing each scale with a distinct rounded dark spot occupying rather less than half the exposed area; scales in lower region macroscopically immaculate though bearing in some parts, particularly immediately beneath the lateral line, some disperse minute brown chromatophores. Ventral surface of trunk and tail pale orange except for a conspicuous bright pink patch on either side behind the branchiostegal membrane, extending back just beyond level of pectoral base and continuing upward partly to embrace it, between these patches burnished silver. Head in general like trunk similarly bicolor, some pinkish lights on side of snout, silvery on parts of operculum and preoperculum; iris silvery pink with internal and external dusky bounding annuli, pupil silvery.

Dorsal pink, in (b) with five subvertical black streaks on first five membrane panels and some smoky spots or smudges on rest of membrane in anterior two-thirds of fin. Anal and pectoral both pale pink immaculate. Ventral whitish or pinkish, a blackish area near tip not involving outer ray and of diminished intensity on adjoining ray. Caudal minutely and in general rather sparsely punctulated with dark brownish or blackish but overall mostly off-white, a conspicuous mark intensely black with indications of a pink annulus in upper half just behind middle of length, in (a) in the form of a longitudinal elliptical spot with major diameter 3.5 mm, in (b) of similar size but consisting of two longitudinal streaks separated by an uncolored ray, in both specimens an irregular dark patch shortly behind base near upper margin, some faint duskiness at middle of base.

Markings on the caudal in (a) are overall quite similar to those in the illustration of the Promise Bay fish in Part XIX (1974a, fig.2) though the dark median basal spot there shown is only faintly indicated here. This figure, the only representation of the species at present available, provides no indication of the strong pigmentation found in the upper half of the trunk and tail in both the present examples or of the dark markings on the dorsal fin evident in (a).

General features

The general features have been tolerably well dealt with in the detailed account of the Promise Bay specimen in Part XIX. However, two additional points call for notice.

Beyond the fact that they are there noted as being cycloid no information on the scales is recorded. A typical scale exhibits an unusual and highly characteristic form, being subelliptical and notably elongate, modally with the major (longitudinal) axis about 5 mm the minor axis about 1.5 mm, exposed margin acutely pointed, briefly free of striae; anterior (embedded) border rather more rounded with about a dozen scallopings from which strong primary striae run backward to converge almost to a point at a small ovate focus at about the middle of the length of the scale, the chord of the arc formed by their free extremities one-fourth or less the length of the longest

(median) stria; closely set between these ridges the usual minute wavy tertiary striae; rest of scale, apart from free tip, with two series, each from about a dozen to about a score, of somewhat sinuous longitudinal secondary striae.

A feature exhibited by the present species and widespread if not universal in the genus *Neoodax* that has not been the subject of general notice is the presence between the eye and the inferior profile (frequently extending forward in advance of the level of the front of the orbit) of a longitudinally elongate smooth platform suggestive of a facet on a cut gem. This is seldom evident in illustrations such as those in the State catalogues of McCulloch (1922) and of Scott *et al.* (1974) for New South Wales and South Australia respectively or in the figures in the review of Western Australian Odacidae by J.K. Scott (1976). It may be clearly seen (with some undue clarity incidental to the nature of a line drawing) in Part XIX (1974a, fig.2).

Aspects of form

(a) *Head, length to vent, standard length.* When these three dimensions are plotted on a loglog grid at abscissal values of 1 5 10 they fall effectively collinear. As is usual in comparable computations for other species the full length of the head is taken including the opercular lobe. Of the subjoined equations the first is that for the earlier Promise Bay specimen.

Log L = 0.6370 log N + 2.3641; t 231.086**; measured (predicted) lengths as millesimals of standard length 231(231) 647(645) 1 000(1 003).

Log L = 0.6492 log N + 2.3464; t 54.901*; 233(222) 622(631) 1 000(990).

Log L = 0.6550 log N + 2.3508; t 47.428*; 223(224) 656(644) 1 000(1 013).

Log L = 0.6429 log N + 2.3553; t 143.961**; 227(227) 639(638) 1 000(996).

It is of interest to note that in the other very elongate form, *N. beddomei*, the greater relative length of head (340 *TLs* units as against 223-237 mean 228.5 for four examples of *N. attenuatus*) is compensated by a decrease in relative length of trunk (343, *cf.* 399-413.8) of such a magnitude that the logarithmic dimensions length of head length to vent standard length yield a good approximation to linearity (t 17.261*) when they are plotted on the same abscissal points (logs 1 5 10) as those specified above for the present species; though a marginally better fit (t 19.732*) is found with abscissal logs 1 4 10. The range of *N. beddomei*, till recently known only from the (lost) holotype and the second Tasmanian specimen described and figured in Part XVI (1969), has now been considerably extended by the report (J.K. Scott 1976) of four examples, *Ls* 59-98, from Carnac Island and Canal Rocks, Western Australia.

(b) *Location of unpaired fins.* The locations of the fin origins and terminations along the general anteroposterior axis of the fish are such that in a loglog plot they are significantly linear on 2 6 7 8 10. First equation that for Promise Bay specimen, all dimensions as *TLs*.

Log L = 0.8959 log N + 2.1163; t 53.017 ; measured (predicted) lengths 241(243) 660(650) 760(747) 847(842) 1 000(1 028).

Log L = 0.8976 log N + 2.0992; t 36.039; 233(234) 638(628) 739(721) 777(812) 1 000(993).

Log L = 0.8941 log N + 2.1235; t 27.492; 243(247) 676(660) 794(757) 840(853) 1 000(1 041).

Log L = 0.8852 log N + 2.1178; t 76.202; 241(247) 649(641) 745(734) 814(826) 1000(1 007).

Family URANOSCOPIDAE

Four uranoscopids are known from Tasmania: (a) *Kathetostoma laeve* (Bloch & Schneider, 1801) (b) *Kathetostoma giganteum* Haast, 1873 (c) *Genyagnus monopterygius* (Bloch & Schneider, 1801) (d) *Gnathagnus innotabilis* Waite, 1904. Of these (a) appears in all published local lists and was included in the earlier still-unpublished list of Allport, and is not uncommon in our waters, (b) was first reported from this State in Part XX (1974b), (c) is not included in the local catalogues of Johnston (1883, 1891) Lord (1923, 1927) Lord & Scott (1924), but is credited to Tasmania in the Australian Check-List (McCulloch 1929) (no recent occurrences are reported), (d) appears first to have been noted by Mr A.P. Andrews, Curator of Vertebrates, Tasmanian Museum, Hobart, who mentioned to the writer in a letter dated 6 May 1972 he had recently examined an example — Mr P.R. Last, Tasmanian Fisheries Development Authority, informs me this species is noticed in a paper by him the publication of which is expected to precede that of the present communication.

Two specimens of *Kathetostoma giganteum* recently added to the collections of the Queen Victoria Museum, Launceston are here noticed and observations are made on three examples of *Gnathagnus innotabilis* from Tasmania and four from New South Wales, including a syntype, courteously made available for examination by the Australian Museum Sydney.

KEY TO URANOSCOPIDAE RECORDED FROM TASMANIA

1. Scales present. No spine in front of ventral fin.....2
   Scales absent. A strong forwardly directed spine (often concealed in flesh) in front of each ventral fin 3
2. Lower jaw normal. A barbel on chin..... *Genyagnus monopterygius*
   Lower jaw with a pair of large processes meeting in front of chin. No barbel on chin..... *Gnathagnus innotabilis*
3. D. 13-16. A. 13-15. P. 15-20. With broad dark cross bars, dark blotch on the preoperculum, side not or faintly and unextensively marbled, no white streak along lateral line..... *Kathetostoma laeve*
   D. 16-18. A. 16-18. P. 20-21. Without broad dark cross bars, without dark blotch on the preoperculum, side strongly and extensively marbled usually with inclusion of some white spots or blotches, a white streak along lateral line..... *Kathetostoma giganteum*

The third Australian species of *Kathetostoma*, the deep-water *K. nigrofasciatum* Waite & McCulloch, 1915, known from Western Australia and South Australia, might perhaps be met with in our waters with an increase in trawling. It can be distinguished from the two species keyed above by its having the interoposterior border of the orbit rounded instead of pointed and the minimum width of the naked interorbital region about one-third instead of half or more the total interorbital width.

Genus *KATHETOSTOMA* Günther, 1860

Kathetostoma Günther, 1860, CAT. FISH. BRIT. MUS., 2, p.231. Type-species, *Uranoscopus laevis* Bloch & Schneider, 1801.

Kathetostoma giganteum Haast, 1873

Kathetostoma giganteum Haast, 1873, *Trans. N.Z. Inst.*, 5, p.274, pl.16, fig.2.
Type locality: Heathcote estuary, near Sumner, New Zealand.
Kathetostoma giganteum: Waite, 1911, *Rec. Canterb. Mus.*, 1(3), p.241: Waite & McCulloch 1915, *Trans. R. Soc. S. Aust.*, 39, p.471: Phillipps, 1921, *N.Z. J. Sci. Tech.*,

4(77), p.123, and 1927, *N.Z. Mar. Dept Fisher. Bull.*, 1, p.43 (N.Z. references): Mees, 1960, *J.R. Soc. W. Aust.*, 49(3) pp.47 56: Whitley, 1968, *Aust. Zool.*, p.69: Scott, 1974, *Pap. Proc. R. Soc. Tasm.*, 108, p.187.
Kathetostoma laeve: Hutton, 1872, CAT. FISH. N.Z., p.23. *Non Uranóscopis laevis* Bloch & Schneider.

Distribution

The range of this species was extended from New Zealand to Tasmania by the record in Part XX (1974b, p.187) of a specimen, *Ls* 316 *Lt* 390, netted at Coles Bay, east coast, in November 1972 by Mr R. Standage (Q.V.M. Reg. No. 1972/5/617). It was noted that the specimen, which differed strikingly in general appearance from all 9 examples of *Kathetostoma laeve* (Bloch & Schneider, 1801) on which observations were presented earlier in the same paper, was determined on criteria set out by Waite & McCulloch (1915), rather than on those of Haast's original account — some difficulties in that account are considered below.

Material

Two specimens (a) *Ls* 195 *Lt* 240, trawled off the east coast, 147° 32' — 148° 25' E, 41° 31' — 43° 10' S, in 78-107 m by the Tasmanian Government fisheries vessel *Challenger* in August 1979 (Q.V.M. Reg. No. 1979/5/164) (b) *Ls* 225 *Lt* 310, taken by Mr Shane Down in 22 fathoms (40 m) north of Eddystone Point, east coast, 18 July 1979 (Q.V.M. Reg. No. 1979/5/90).

Meristic characters

D. 16,16. A. 17,16. P. 20,21. C., main rays 11,11. V. 1,5. Of these counts A. 16 and P. 16 are each one fewer than the smallest number given in what is effectively the definitive account of this species, that of Waite (1911).

Dimensions as *TLs*

A series of 31 measurements made on the specimen of this species reported in Part XX (1974b, p.186) and there recorded along with ranges, means with standard error and coefficient of variation for a sample of 9 examples of *Kathetostoma laeve* have been repeated for the two present fish and are noted below (values of earlier example in parentheses).

Length to origin termination of dorsal 569 553 (611) 892 851 (927), of anal 545 528 (581) 910 939 (927). Length to origin of pectoral 297 240 (193), length of fin 374 353 (386). Length to origin of ventral, at anterior of girdle 92 69 (57) [this measurement is here taken from anteroexternal angle of pre-fin rhomboidal region], at insertion of spine 128 118 (95), length of fin, from anterior border of girdle 256 271 (282), from insertion of spine 236 212 (186). Length of caudal 231 230 (234). Length to vent (middle) 492 536 (541).

Head, to hind border of operculum 297 310 (294), to midpoint on hind border of armature 241 235 (259). Length to base of humeral spine 385 337 (389). Eye, with fleshy rim 51 48 (41), without rim 47 31 (38). Bony orbit, between midpoints of anterior and posterior borders 53 49 (46), between midpoints of lateral borders 55 38 (48). Interocular 87 89 (85). Snout, from [mesial] tip of upper jaw 24 26 (25), from most advanced point (chin) 85 78 (79), latter in advance of former by 61 52 (54). Depth, maximum 221 200 (228), at vent 210 196 (209), at caudal peduncle 87 86 (87). Width, maximum 297 333 (364), at front of eyes 205 212 (209), at back of eyes 210 255 (275), at vent 236 220 (225).

Some other relevant proportions may be noted. Dorsal base 3.10 3.14 (3.16) anal base 2.73 2.43 (2.89) in standard length. Dorsal base 1.13 1.29 (1.09) in anal base. Length of pectoral 1.26 1.14 (1.31) head. Length of ventral 1.39 1.46 (1.58) in head.

Length to vent 2.03 1.96 (1.84) in head. Maximum depth 1.35 1.67 (1.60) in maximum width.

Specimen (a). Trunk and tail: dorsal surface, its margins virtually defined by the lateral line, with some brief greyish marbling immediately behind head, then wholly black back to level of dorsal origin, beside first one-fourth of dorsal base marbled greyish and brownish, along rest of very narrow strip between lateral line and fin blackish, finally behind fin, where lateral line dips down on caudal peduncle, heavily marbled with very pale greyish; lateral line overall a whitish streak, constituted by small largely confluent or contiguous subelliptical or subcircular whitish patches; upper half of lateral surface wholly mottled with mid brown and pale grey or white, the brown more extensive in one obscure bar back to level of dorsal origin and one below most of hinder two-thirds of the fin base (these dark areas apparently rudiments or vestiges of the distinct dark cross bars found in *K. laeve* and in an even more pronounced form in *K. nigrofasciatum*); rest of lateral surface and whole of ventral surface pearly white. Head: general color of dorsal surface light greenish brown, naked interorbital basin somewhat more dusky, supraorbital ridges and in lesser degree rest of bony orbit very pale yellowish; that part of lateral surface covered with amount concolorous with dorsal surface, thence greyish mottled with dark brown down to midlateral line, below this more or less whitish with a few obscure greenish brown smudges, no dark patch on preoperculum this region concolorous with rest of head, ventral surface white, lips pale somewhat yellowish green obscurely marbled with greenish brown, inside of mouth white.

Fins: dorsal mostly dark grey, whole of first ray, outer parts of other rays with a brownish streak, occupying half second ray decreasing in extent in remaining rays, absent in last, tips of rays white or off-white; anal whitish, minutely punctulated with brownish or brownish green, this pigmentation wholly absent from ray tips, a very narrow brownish streak just below the small scallops of the membrane; pectoral base and first one-fourth of fin white, rest dark brownish save for white tips to all rays; ventral almost wholly white or whitish, two (right fin) or three (left) faint darkish smudges between rays distally; caudal much like pectoral, tipped with white.

Specimen (b). In general pattern the larger individual closely resembles the smaller. Chief differences: dorsum in advance of dorsal origin not so dark and lacking the brief anterior mottling; marbling on flank not quite so well defined, extending further down, on tail right down to ventral profile; ventral surface isabelline; anal more dusky, especially proximally; pectoral base briefly greyish the light color not extending noticeably on to rays; ventral with much more extensive dark smudging, overall dark grey except for off white tips of rays.

Aspects of form

(a) *Head, length to vent, standard length.* In both the present specimens and the Coles Bay individual the logarithms of length of head length to vent standard length are significantly collinear on the logarithms of 1 2 5 (dimensions below as *TLs*).

Log L = 0.7544 log N + 2.4704; t 57.583*; measured (predicted) lengths 297(295) 492(498) 1 000(997).

Log L = 0.7252 log N + 2.4984; t 23.578*; 310(315) 536(521) 1 000(1 012).

Log L = 0.7315 log N + 2.4960; t 17.386*; 293(313) 540(520) 1 000(1 017).

It is of interest to note that when the mean lengths for the 9 individuals of *Kathetostoma laeve* recorded in Part XX (1974b) are similarly treated the graph is linear on 1 2 6.

Log L = 0.6367 log N + 2.5058; t 77.486**; 320(320) 502(498) 1 000(1 008).

(b) *Head in plan.* With measurements made at 10 equal intervals (N, counting caudad) and expressed as percentages of length to level of lower lobe of operculum (W)

the equations for the head in plan of the present specimens are as set out below, together with the corresponding equation for an example of *Kathotostoma laeve*, *Ls* 375, from Sandy Beach, Tamar River (Q.V.M. Reg. No. 1972/5/660).

$W = 45.18 + 15.878\ N - 0.929545\ N^2$; R 0.9916; measured (predicted) widths 59(59) 75(73) 84(84) 93(94) 100(101) 107(107) 113(113) 113(113) 111(110).

$W = 35.52 + 20.165\ N - 1.20076\ N^2$; R 0.9981; 53(52) 68(68) 79(83) 94(94) 105(103) 113(110) 114(115) 115(117) 118(117) 114(114).

$W = 50.78 + 18.262\ N - 0.81932\ N^2$; R 0.9964; 72(68) 81(84) 96(98) 110(111) 121(111) 121(122) 135(139) 144(144) 148(147) 151(151).

Hence for the present examples of *K. giganteum* $\frac{dW}{dN} = 15.878 - 1.8591\ N$ and $20.165 - 2.4015\ N$; equating to zero gives maxima for W at 8.54 N and 8.40 N, the greatest width thus being found at 85.4% and 84.0% of the relevant anteroposterior lengths (57 80 mm), i.e., at 47.7 and 67.2 mm from snout tip. At -1.86 and -2.40 the tangents are indicative of a decidedly obtuse head, though less obtuse than that of the specimen of *K. laeve* examined (a larger individual *Ls* 375, *cf.* 195 225) with a tangent of -1.64. For this material the maximum width in *K. giganteum* is 1.13 1.18 length from tip of snout to level of lower angle of opercular lobe, in *K. laeve* 1.51. It should be observed, however, there is some evidence to suggest the possibility that the outline of the head may vary to some extent with overall size of fish (*cf.* table 5); further investigation involving larger samples with wider length ranges is needed before satisfactory interspecific comparisons can be instituted.

(c) *Girth*. The girth as represented by 10 measurements made at equal intervals from just behind level of insertion of humeral spine to caudal origin is satisfactorily fitted (R 0.9968 0.9990) by the following equations, dimensions being given as percentages of the anteroposterior lengths involved (130 150 mm).

$G = 130.24 - 11.335\ N + 0.16212\ N^2$; measured (predicted) girths 123(119) 105(108) 96(98) 85(87) 78(78) 69(68) 62(59) 52(50) 42(41) 31(33).

$G = 138.94 - 8.280\ N + 0.15745\ N^2$; 131(131) 121(122) 110(113) 103(103) 95(94) 85(84) 73(73) 61(63) 50(52) 41(40).

Discussion

In general form *K. gigamteum* differs little from *K. laeve* and *K. nigrofasciatum*. Unfortunately the history of Haast's species has not been free from uncertainty and indeed error. His original account, which included only one proportional dimension ('length of the head is four times in the total'), instituted no comparison with any other species of the genus (neither of the Australian species *K. laeve* nor the subsequently described *K. nigrofasciatum* occurs in New Zealand (Whitley 1968), but *K. fluviatilis* Hutton, 1872, with type locality Manawatu River, New Zealand, predated *K. giganteum* by a year). The reported fin counts were D.16. A. 16. P.22. C.11; however, Waite (1911, p.243) stated 'an examination of the type specimen shows the formula of the fin rays has been incorrectly rendered in the description', and gave D.18 A.17 or 18. V.I,5. P.22. C.11 (earlier, on p.241, he had noted for his own material P.21). In his basic New Zealand list Waite (1907) omits *K. giganteum* incorrectly including *K. laeve*. The ascription to the ventral of five rays (without a spine) is understandable, the spine being wholly included in flesh with the adjoining ray.

Attention may be appropriately called at this point to the question of variability in fin counts met within this genus. A key by Scott *et al.* (1974, p.264) to the three uranoscopids recorded from South Australia (including *Ichthyoscopus barbatus* Mees, 1960) specifies for *K. laeve* 'Dorsal fin with 15-16 rays; orbit pointed behind'[i.e., at posterointernal border] and for *K. nigrofasciatum* 'Dorsal fin with 13-14 rays; orbit rounded behind'. Further, in the text the pectoral count for *K. laeve*, at 15-16, differs trenchantly from the 19 given for *K. nigrofasciatum*, and there is a difference also in anal counts, namely 14-15 and 13-14. However, in an examination of 9 examples of

K. laeve reported in Part XX (1974b) counts of 13-16 were found for dorsal rays 13-15 for anal rays and 15-20 for pectoral rays. It is thus apparent some current specific diagnoses lack validity in the absence of more satisfactory information on fin counts. An added uncertainty has been noticed by Mees (1960, p.56) 'Günther's (1860) count for *K. laeve* is also high, higher than one would expect for that species, and if this count correctly represents the fin-ray formula of his specimen, they are likely to belong to *K. giganteum*, a species not described at that time, and not to *K. laeve*'. A similar confusion surrounds (Phillipps 1927) the count given by Hutton (1872). On the basis of our present knowledge as set out above in the key to uranoscopids recorded from Tasmania the ray counts for *K. giganteum* and *K. laeve* are disjunct only in the case of the anal (16-18 13-15) with intersection in the dorsal (16-18 13-16) and the pectoral (20-21 15-20), including, however, for both of these fins a higher maximum for *K. giganteum*.

The illustration provided by Haast (1873, pl.16) is clearly inept and is in some features erroneous. Thus the dorsal is shown as originating well in advance of the anal, while actually, as reported by Waite (1911, p.242), the anal has the more anterior beginning: in the figure the anal originates at about 62% of the standard length, in our specimens at 55 57%. In the figure the dorsal base is approximately 1.2 of the anal base (measured between parallels), whereas in the present examples the shorter dorsal base is 0.88 0.74 that of the anal.

Waite & McCulloch (1915, p.471) state the surface of the exposed bone on the head is sculptured into 'reticulating ridges' in *K. laeve* into 'tubercles' in *K. nigrofasciatum*, while *K. giganteum* is noted as being distinct from both by virtue of the 'granular' sculpture. While the features mentioned tend to predominate in the three species as described some admixture of the modes occurs so that the nature of the sculpture does not present an absolute criterion.

Together with the regularly greater number of rays in the anal and the generally greater number in the dorsal and the pectoral, *K. giganteum* is most readily distinguished from both the other Australian species of the genus by the color pattern, particularly in the absence of the distinct dark cross bands on the body and in the presence of the marbling on the upper part of the trunk and tail and of a white streak along the lateral line (not reported by Haast); further, from *C. laeve* in the absence of the dark subopercular patch.

Genus *GNATHAGNUS* Gill, 1862

Gnathagnus Gill, 1862, *Proc. Acad. Nat. Sci. Philad.* (1861 session), pp.111 115. Type-species, *Uranoscopus elongatus* Temminck & Schlegel.

Gnathagnoides Whitley & Phillipps, 1939, *Trans. R. Soc. N.Z.*, 69, p.235. Type-species, *Gnathagnus innotabilis* Waite.

Gnathagnus innotabilis Waite, 1904
(plate 2)

Gnathagnus innotabilis Waite, 1904, *Rec. Aust. Mus.*, 5(4), p.238, pl.16, fig. 1. Type locality: Off Narrabeen, New South Wales.

Gnathagnus innotabilis Waite, 1911, *Rec. Canterb. Mus.*, 1, p.243: Phillipps, 1927, *N.Z. Mar. Fisher. Bull.*, 1, p.43: McCulloch, 1922, *Aust. Zool.*, 2(3), p.102, pl.32, fig. 281a and 1929, *Aust. Mus. Mem.*, 5(3), p.335: Mees, 1966, *J. R. Soc. W. Aust.*, 43(1), p.47.

Gnathagnoides innotabilis grandior Whitley & Phillipps, 1939, *Trans. Proc. N.Z. Inst.*, 69, p.235. Type locality: New Zealand.

Gnathagnoides innotabilis grandior: Mees, 1960, *J. R. Soc. W. Aust.*, 43(1), p.47: Whitley, 1968, *Aust. Zool.*, 15(1), p.69.

Gnathagnoides innotabilis Whitley, 1964, *Proc. Linn. Soc. N.S.W.*, 89(1), p.53.

Note on synonymy

With regard to the status of *Gnathagnoides* Whitley & Phillipps the writer finds himself in agreement with the view expressed by Mees in his important review of the Uranoscopidae of Western Australia that the differences between *Gnathagnus innotabilis* and the type species of *Gnathagnus* Gill are 'much too slight to justify generic separation' (1960, p.47); while, again as observed by Mees, the establishment of *Gnathag-Gnathagnoides innotabilis grandior* solely on the ground of greater size of specimens taken in New Zealand (presumably those noted by Waite (1911, p.244), no mention being made of additional material examined) would clearly seem to be unacceptable. (It may be noted in passing that the relevant page number in the 1939 paper of Whitley & Phillipps is given by a typographical error in Mees' paper as 225 instead of 235 near the top of p.47, though correctly cited lower in the page.)

Distribution

Originally described from New South Wales — where later McCulloch (1922, p.102) noted it as not uncommon in moderately deep water — it was subsequently reported by Waite (1911, p.243) as being represented in five of nine hauls made at 25-94 fathoms (46-172 m) by the New Zealand Government trawling expedition in the Bay of Plenty in 1907. No other localities appear in the Check-List (McCulloch 1929). Though it is not included in any of the published Tasmanian catalogues, it is now known to occur here (see note above on the family Uranoscopidae).

Material

Eight examples, (a) *Ls* 125 *Lt* 155, 4 miles (6 km) southeast of Eddystone Point, east coast, Tasmania, in 20 fathoms (37 m), July 1979, Mr S. Down (Q.V.M. Reg. No. 1979/5/95), (b) *Ls* 135 *Lt* 169, one of three syntypes, off Narrabeen, New South Wales, 151° 19' E, 33° 43' S (Aust. Mus. Reg. No. I 6152), (c) (d) (f) *Ls* 175 185 223 *Lt* 218 223 272, northeast of Babel Island, Bass Strait, in 70-100 fathoms (130-180 m) (Aust. Mus. Reg. Nos. E 4939 E 4940 E 4941, registered 1914, *Endeavour*), (e) (g) *Ls* 209 225 *Lt* 255.5 278, off southeast coast, Tasmania, 147° 32' - 148° 25' E, 42° 31' - 43° 10' S, trawled in 78-107 m by the Tasmanian Fisheries Development Authority's vessel *Challenger*, Mr P.R. Last, August 1979 (Q.V.M. Reg. No. 1979/5/163), (k) *Ls* 252 *Lt* 310, off St Helens Point, east coast, Tasmania, in 5 fathoms (9 m), Mr S. Down, 1 August 1978 (Q.V. (Q.V.M. Reg. No. 1978/5/101). The courtesy of the Australian Museum in making available for examination specimens (b) (c) (d) (f) is gratefully acknowledged.

Meristic characters

D.12 (7 specimens) 13(1). A.15(1) 16(7). P.19(3) 20(1) 21(4). C. total rays 15(2) 16(3) 17(3), branched 10(4) 11(4), reaching distal border 10(1) 11(7). Gill rakers on lower limb of first arch about 17-20, low mounded each with several acute processes.

Dimensions

A set of dimensions of all 8 examples is set out in table 3, the first line, standard length (*Ls*), being in millimetres all other lines as thousandths of standard length (*TLs*).

Proportions

For all the 11 proportions selected by Waite for record in the original account of the species there are here given the range and the mean (with standard error) for our material with Waite's variates in parentheses. Head in total length 3.2-3.7 3.40 ± 0.0528 (3.0). Depth in total length 5.3-7.9 6.89 ± 0.317 (4.4). Length of head in width of head 0.8-1.1 0.87 ± 0.306 (width one-fourth more than length). Eye in head 5.4-6.9 5.84 ± 0.179 (4.3). Interorbital in head 2.6-3.3 2.99 ± 0.0883 (2.2). Snout in head, measured from midpoint of front of upper jaw 6.3-9.6 8.19 ± 0.363, from level of front of maxilla 4.7-6.9 5.68 ± 0.274, from most advanced point (chin) 3.0-3.7 3.33 ± 0.079 (convention of measurement not specified 6.5). Depth of caudal peduncle

in head 4.2-5.2 4.77 ± 0.128 (3.5). Length of pectoral in total length 3.3-6.5 4.67 ± 0.425 (4.0). Length of ventral in total length 5.0-7.2 6.25 ± 0.231 (5.2). Length of caudal in standard length 4.1-5.0 4.47 ± 0.117 ('4.3 in the body'). Anal base in head 0.9-1.1 1.02 ± 0.0265 ('slightly more than the length of the head').

Some further significant ratios may be noted. Dorsal base in standard length 3.9-4.6 4.17 ± 0.0712. Anal base in standard length 2.6-3.1 2.85 ± 0.785. Dorsal base in anal base 1.3-1.6 1.44 ± 0.0354. Length of pectoral in head 0.9-1.4 1.13 ± 0.0554, of ventral 1.5-2.2 1.85 ± 0.213, of caudal 1.6-1.7 1.61 ± 0.0176. Maximum depth of head in head length 1.6-2.5 2.0 ± 0.102, in maximum width of head 1.5-2.0 1.75 ± 0.470.

Of the above ratios four exhibit significant positive correlation with standard length, namely, length of pectoral in head r 0.912 (z 1.540) t 5.442**, length of ventral in head r 0.941 (z 1.746) t 6.804***, length of ventral in total length r 0.865 (z 1.314) t 4.230**, maximum depth of head in head length r 0.871 (z 1.337) t 4.343**. One ratio, length of head in width of head, is correlated negatively with standard length, r − 0.795 (z − 1.084) t 3.206*.

General features

Our basic knowledge of this species is afforded by the original description (Waite 1904) based on three syntypes from New South Wales, the subsequent notice by Waite (1911) in his report on the New Zealand Government trawling expedition of 1907 merely extending range and overall size, and no additional information on external features being provided by Whitley & Phillipps (1939) in establishing their genus *Gnathagnoides* and in proposing a New Zealand subspecies *G. innotabilis grandior*. The immediately following observations, based primarily on the largest Tasmanian individual, supplement and make minor emendations to the original account, while a later section, Aspects of form, explores some characters not previously investigated.

More or less fusiform. Pectoral reaching to level of vent or to just beyond anal origin. Ventral reaching about to level of pectoral base. Caudal truncate.

A characteristic feature is the presence on the head of the curious plectroid processes that cover most of the chin, constituting the effective front elevation of the head. The greater part of each process is tolerably rigid, brown mottled with grey; upper border of each in contact with outer one-third of lower lip, extending down and back beyond lip to end of mandible, in upper one-third remaining in contact with one another, in lower one-third their bluntly rounded free ends meeting and touching or freely overlapping, in middle one-third largely continuous but leaving a median elliptical opening, its width twice its height subequal to length of orbit, the chin here being exposed to view as through a window; greater part of each process tolerably rigid, brown irregularly mottled with grey, lower border from middle of lower margin of window down and back to vertical level of end of lower lip constituted by a white and off-white strongly denticulate and ridged soft fleshy edging. Mouth cleft large, vertical, lips wholly lacking cirri. Nostrils minute, approximately in line with highest point on orbit, anterior subcircular with low rim and very small tentacle, posterior a slit with a low rim with an obscure fleshy fringe. Teeth in upper jaw rather widely spaced small slender acute recurved depressible, mostly in two rows those of inner row larger (several near median line larger than remainder) and often set alternately with those of outer; in lower jaw much as in upper but somewhat larger; on vomer two ovoid patches, interspace subequal to width of one, each with half a dozen small teeth similar to those in jaws interspersed among more numerous small mammilliform elevations (contrast Waite 'villiform'); on pharyngeal on each side a patch much as on a moiety of vomer. Tongue with minute ridges or lines of papillae, chiefly transverse. A minute fleshy lobe, usually wholly white, at the symphysis of the premaxillae.

PLATE 2. *Gnathagnus innotabilis* Waite, 1904. Dorsal aspect of head of a specimen, standard length 223 mm, total length 272 mm, northeast of Babel Island, Bass Strait, in 70-100 fathoms (130-180 m) (Australian Museum Reg. No. E 4941, registered 1914, *Endeavour*), x 1 1/2. (Photograph R.H. Green).

Bony armour on head as illustrated (plate 2). Most important features: a pair of apposed occipital plates together constituting a trapezoid, its wider (posterior) border half width of head here, each with a short thick median ridge or longitudinally elongate boss occupying middle third of the length ('a longitudinal ridge passing from its middle backwards') from which radiate upwards of two dozen short straight much lower ridges forming a rosette; an ill-defined broken ridge running back and out from posterolateral angle of orbit towards humeral spine; inside this and in advance of occipital rosette of fan of 10-12 ridges; a fan of about a dozen ridges radiating from top of operculum to its lower margin; a smaller fan directed in opposite sense on preoperculum; preorbital rugose with 2-3 small upwardly convex ridges reaching its anterior border; a rugose strip with 2-3 ill-defined ridges running from near posteroexternal angle of occipital plate towards humeral spine, the latter small flattened blunt, or moderately pointed directed back and slightly down, almost flush. In the syntype and the Tasmanian specimens 4-5 small rather obscurely defined mostly subcircular plates with rosettes of ridges can be made out along and somewhat beyond hind border of each occipital plate with which the inner ones are continuous: in the *Endeavour* specimens (b) (c) (d) these plates are islands and being dark purplish or almost black on a light brownish background form a conspicuous part of the ornamentation (plate 2). Interocular basin occupied only by naked integument more or less trapezoidal, somewhat rounded at its posterior border, its width behind one and a half times that in front, latter about four times shortest distance from the side to supraorbital ridge.

Scales occur on dorsal and lateral surfaces of trunk and tail, being absent from a small median patch, somewhat larger than eye, just behind occipital plates, from a narrow strip along each side of dorsal and anal bases and from inner surface of pectoral base; on ventral surface present backwards from near level of vent; continued on to caudal base and up the rays and membrane for some two-thirds of fin length. Waite observes they 'lie in depressions resembling the pits of a thimble'; however, these pits occur only on the dorsal surface, scales on ventral surface of tail being quite flush. A scale from dorsum shortly behind head is cycloid lanceolate, rounded at exposed pointed at embedded end; length about 1.7 mm about three times greatest width; exposed pigmented portion accounting for only about one-sixth of length; focus of striae shortly behind pigment: a scale from ventral surface near anal origin similar but somewhat smaller, lacking patch of pigmentation.

The lateral line is noted by Waite as arising above the humeral spine and running an undulated course to the middle of the caudal fin. In the largest Tasmanian example the two lines originate 53 mm apart above the humeral spine by about the spine's length, run almost straight approximating backwards to be 40 apart an eye diameter in advance of dorsal origin, continuing in a course at first gently concave inwards then gently convex to level of dorsal termination, here 20 apart, thereafter turning slightly downward to meet the caudal base equidistant from dorsal and ventral borders of the peduncle.

Aspects of form

(a) *Head, length to vent, standard length.* On a loglog plot these three cardinal lengths are collinear when the abscissal values are 1 2 7. The relevant statistics are exhibited in table 4: it will be seen that in one of the eight cases significance falls just short of the formally acceptable level of P 0.05.

(b) *Head.* From the most advanced point of the head, the chin, modally located at some three-sevenths of the height between the distal border of the maxilla and the top of the lips, the dorsal profile rises briefly but sharply in a convex or biconvex curve to level of mouth cleft behind which the remaining head profile is virtually horizontal, while from the chin the lower part of the profile slopes back and down at an angle of 40°-50° to below the much-expanded maxilla thereafter continuing horizontally.

As table 3 renders evident the anterior border of the maxilla extends in advance of the level of the middle of the upper lip.

In plan the head is parabolic. Widths (W) have been measured at 10 equal intervals (N, numbered caudad) between most advanced point and level of opercular at visual ventral plane for all specimens and second-degree equations calculated — statistics being set out in table 5. In these equations and in the discussion below widths are expressed, to permit valid comparison between individuals, as percentages of the relevant anteroposterior lengths.

Though highly acceptable fits in general result (R 0.8649-0.9989, $\bar{x}$ 0.9759), the parameters exhibit some noticeable variation and the general head outline differs greatly in small and larger individuals, the anterior border of the snout being quite obtuse, almost transversely linear, in the former and well rounded in the latter: indeed, a comparison of our specimens (a) and (h) without reference to other examples of intermediate size might well suggest the existence of two species. Reference to the table shows the tangent manifests a general trend towards decrease in magnitude from the smallest fish to the largest but one, the largest apparently being an outlier. With the omission of the last-named value the remaining 7 entries show significant negative correlation with standard length indicative of increase in pointedness with overall size (and presumably age); r — 0.854 (z — 0.636) t 4.868**. The greater relative width anteriorly in the smaller examples is strikingly evident in the following data: relative width (percentage of head length) at the level of the most anterior measurement (N = 1) ranges from 65.1 in the smallest individual to 34.7 in the largest and is significantly correlated with standard length, r — 0.923 (z — 1.161) t 5.893**; similarly for N = 2, r — 0.908 (z — 1.515) t 5.300**; for N = 1 as a fraction of maximum value of N, r — 0.799 (z — 1.097) t 3.259*.

Not only the form of the outline of the head but also the relative area of the dorsum as a whole is age (or size) related. Thus the sum of the 10 widths expressed as percentages of the conventional length of the head ranges down from 98.51 in the smallest fish to 73.92 in the largest, the correlation with standard length being r — 0.794 (z — 0.885) t 3.202*.

(c) *Disposition of fins.* The lengths from snout tip to the origins of the pectoral anal dorsal, to the terminations of dorsal anal and to the origin of the caudal are such that when plotted in that sequence on a loglog grid they fall collinear when given as abscissal values the integral numbers 1 3 4 7 8 10. The relevant regression equations are set out in table 6, all dimensions being given as thousandths of standard length.

(d) *Trunk and tail.* The single visual unit presented by the combined trunk and tail is a simple one. Though viewed from above the sides are very slightly convex the general outline comes very close to a briefly truncated triangle with the widths at the middle and the posterior end of the region being 0.6 0.1 that at the anterior end. In the largest Tasmanian specimen the first-degree equation derived from 10 measurements of width taken at equal intervals, W = 0.4061 L + 78.9 (measurements in mm) reaches a correlation of r 0.997 (t 38.942***). The anterior one-third od the dorsal profile scarcely departs from the horizontal line of the head but thereafter slopes down to a progressively greater but never large degree.

The resultant girth presents a gently sigmoid curve. With G = girth as percentage of length from back of head to caudal origin (171 mm) N = serial number of measurement (10 taken at equal intervals) G = 112.39 + 3.813 N — 0.5054 N^2; R 0.9361; measured (predicted) girths 108(108) 102(103) 95(96) 90(89) 83(81) 73(71) 61(59) 46(50) 35(37) 27(24).

(e) *Ventral surface, mouth.* From the level of the mouth to the caudal origin the ventral surface is virtually plane. The broad flat fleshy character of the ventrals, their mode of attachment without an elevated base and the presence of a slight depression into which they fit when adpressed combine to make them in the prone position effectively flush with the surrounding surface; the anal when folded to one side produces a negligible departure from the general homaloidal condition; while the lowermost ray of the caudal continues (even when the fin is fully expanded) as near as may be collinear with the lower margin of the caudal peduncle. These features may be presumed to represent a very efficient adaptation permitting the fish to rest in full and close contact with the bottom when observing the general habit of members of this family of lying motionless in wait for prey. It is of interest to note that in the common Tasmanian uranoscopid, *Kathetostoma laeve* (Bloch & Schneider, 1801), in which the ventral fin is inserted partly on the lateral surface the presence of a depression into which it can fit serves again to maintain the planar character of the fish's ventral surface. Also related to the specialized feeding habit is the large and unusually positioned mouth, the anterior border of the upper jaw, which extends through more than two-thirds of the height of the head, being quite vertical.

(f) *Fins.* While the general observations here made are applicable to all five specimens examined, metrical data for the dorsal anal and pectoral fins are recorded for the largest Tasmanian individual only.

The dorsal has the first 3 rays simple, the remainder to the 11th dividing for an increasing fraction of their length up to a maximum of about a half; last 2 rays only briefly divided. The length increases from 1st to 5th then decreases to 13th (last), which is very slender and very close to the 12th, separated from it by an interval less than one-sixth that between 12th and 11th. For the ascendant series $L = b\ N^k$ for the descendant $L = b\ N'^k$, where L = length, mm, N = serial number of ray counting caudad, N' = serial number counting dephalad.

Log L = 0.3232 log N + 1.3374; t 7.656**; measured (predicted) lengths 21.5(21.7) 27.5(27.2) 31.5(31.0) 34.2(34.0) 35.9(36.6).

Log L = 0.8217 log N + 0.7693; t 37.665**; measured (predicted) lengths 6.0(5.9) 10.7(10.4) 13.1(14.5) 18.5(18.4) 22.5(22.1) 26.5(25.6) 28.7(29.1) 33.0(32.5).

Anal membrane more nearly opaque than dorsal; rays strongly recurved having much the general appearance of a hockey stick, much stouter than those of dorsal, consisting of a rachis, fairly rigid in proximal but quite flexible in distal half, divided in distal one-third or so the rami running close together, as in dorsal ramal tips projecting beyond membrane but here only microscopically. Length increasing to 9th, this ascendant set comprising two subsets, the loglog graph after being linear over logs 1-5 then becoming interrupted to continue as a second linear segment, with a greater gradient, on logs 6-9. This pattern is an unusual one. It is in general found that where the ascendant or descendant rays (or spines) do not constitute a single series either they represent two separate series characterized by the fact that the first element of each is appropriately plotted on log 1 or if the whole sequence of logarithmic abscissae is a continuous one it presents a point of inflexion, not being disjunct as here. Behind the 9th the rays regularly decrease in length caudad, their logarithms being linear on logs 1-7 when plotted in reverse order, i.e., cephalad (N'). Lengths below in mm.

Log L = 0.2724 log N + 1.1296; t 16.443***; measured (predicted) lengths 13.4(13.5) 16.4(16.3) 18.5(18.2) 19.1(19.7) 21.1(20.9).

Log L = 0.4525 log N + 1.0152; t 10.622**; 23.5(23.2) 24.6(25.0) 26.6(26.2) 28.8 (28.0)

Log L = 0.1364 log N'+ 1.3241; t 21.120***; 21.1(21.1) 23.2(23.2) 24.5(24.5) 25.5 (25.5) 26.1(26.3) 27.1(26.9) 27.5(27.5).

Pectoral membrane tolerably opaque and fleshy; rays dimorphic the 11 lower with broadly rounded or bluntly pointed tips the outline wholly provided by the membrane, the rest noticeably more slender and with the 2-4 ramal tips slightly projecting. In loglog plots for the largest Tasmanian specimen the rays of the upper border are significantly linear when plotted in the sequence 9-1 on their inverse serial numbers 1-9 (N') giving a negative slope while those of the lower border plotted in the sequence 20-10 on their inverse set serial numbers 1-9 yield a significant positive slope.

Log L = − 0.1051 log N + 1.7342; t 14.090***; measured (predicted) lengths, mm, 43.9(43.0) 44.0(43.6) 44.2(44.2) 44.8(44.9) 44.9(45.8) 45.9(46.9) 47.9(48.3) 51.0(50.4) 54.7(54.2).

Log L + 0.8497 log N + 0.8654; t 77.162***; 55.2(56.3) 53.0(51.9) 49.0(47.5) 41.6 (42.9) 35.0(33.6) 28.8(28.8) 24.0(23.8) 18.7(18.7) 13.9(13.2) 7.1(7.3).

The fin is set low, the bottom of the base being actually on the ventral surface the top about at half the total height at that level.

The ventral fins are massive fleshy organs markedly dissimilar from the tolerably fine and delicate ventrals of most of the Jugulares; rays flattened blunt much divided enclosed in membrane, spine wholly bound up with adjoining ray recognizable only with difficulty, fin bases set close together separated by an interval less than (modally about half) base width, inserted about at level of hind border of orbit. The total restriction of the two fins to the planar ventral surface has already been noted.

With 1st ventral ray defined, as proposed in Part XIX (1974a, p.248) as that nearest to medioventral line of fish (postaxial, farthest from spine), in the most frequently encountered fin pattern the rays increase from 1st to 4th, 5th being somewhat shorter than 4th but noticeably longer than spine. (While the preaxial location of the ray nearest the spine might suggest its selection as the conventional 1st as a logical one, the usual increase in length of the rays taken outwards influenced the choice made, account being taken of the convenience of having this length-number graph, like others then under observation, exhibiting a positive slope.) The pattern here met with is quite dissimilar, five elements, including the spine, increasing in length in sequence postaxially, with the ray here designated the 1st slightly shorter than its neighbour. With lengths of spine and rays 5th-2nd plotted on a loglog grid against the natural numbers 1-5 the graph is significantly linear: the data for all 8 fish are recorded in table 7, lengths being presented as millesimals of standard length. It is to be noted the formula here employed is not a precise one, predicted values for the 2nd ray being consistently higher than measured lengths (difference 3-6 mean 4.5 percent), with predicted values for the 3rd ray concomitantly consistently lower (difference 0.6-5 mean 2.8 percent).

The tabulated relative (*TLs*) lengths are seen immediately to tend to be larger among the smaller individuals: indeed the sum of the lengths of the spine and the four radial elements considered decreases consistently from specimen (a) to (g), with an increase being shown by (h). The correlation of this sum of lengths with standard length gives r − 0.784 (z − 1.065), significant at better than P 0.05 (t 3.096).

Coloration

Some differences in coloration are found between the Tasmanian specimens (a) (e) (g) (h) and the Australian Museum specimens (b) (syntype) (c) (d) (f) (these latter having perhaps suffered some decoloration consequent upon longer preservation) and between all of these and the coloration as described by Waite. The immediately following account is based on the local examples.

Dorsal surfaces of trunk and tail and lateral surface down to midlateral level or somewhat below dark brownish or slate, more or less uniform in (a) (h), in (e) with a number of small subcircular dark grey spots in (g) with some obscure dark splashes.

Waite noted body brown 'with indistinct brown spots'; no such markings evident in our material. Lower lateral surface and whole ventral surface immaculate white in (a), off-white in others with dusky or smoky smudging, most pronounced in (e) confined in (h) to less than half total surface; line of demarcation between dark upper and light lower flank very sharp in (a) well defined in (h) rather indefinite and obscure in others. Waite reported 'sand-coloured areas, below the head, at the base of the ventral fins and on the belly'; such areas not identified here. Dorsal surface of head in general much like that of trunk, but in (h) plated areas warm brown with the conspicuous ridges dark yellowish; naked interorbital region uniform and concolorous with dorsum of trunk in (a) and (h) but in (e) with an extensive splash in (g) with several smaller splashes of light grey; lateral and ventral surfaces resembling those on trunk, distinctly lighter approaching white on hind part of operculum in (a) and (h). Lips concolorous with snout. Inside of mouth white in (a) whitish in others.

Dorsal rays usually light or dark grey except for white divided tips, in (h) with noticeable darkening in distal one-third or less; membrane whitish or pale grey, in (a) somewhat darker in first two interradial panels, in (g) each panel with a triangular dark slip widest distally extending down through whole height between posterior rays and for about an equal absolute distance between anterior rays. Anal rays white in (a) and (e) off-white in (h) reddish brown in (g); membrane wholly white in (a) in others off-white with variable amounts of sparse minute dark punctulation; Waite 'the anal has a median longitudinal brown band'. Pectoral in (a) blackish, lower rays a little lighter, very clearly defined external border of white, in others mostly brownish or dark greyish, some irregular areas lighter than the rest, ray tips close to white; fin base white or whitish, light color extending variably on to bases of rays. Ventral wholly white in (a) in others whitish or light grey with some dusky smudging most pronounced in (h). Caudal much like pectoral but overall somewhat lighter, tipped white, in (a) (e) (h) lowermost ray white sharply contrasting with others.

Specimens (b) (c) (d) (f), which have been subjected to longer preservation, tend in general towards brownish, the smallest (syntype) noticeably lighter than the rest in parts approaching straw. The *Endeavour* specimens differ strikingly from the syntype and from all the Tasmanian fish in having the main plated areas on the dorsum of the head dark purplish or blackish; the small detached shields forming a line immediately behind the posterior border of the large continuous armoured region that in the syntype and in the local examples are concolorous with the trunk and barely evident are here also dark purplish almost black, constituting a conspicuous feature of the color pattern.

Comparison with *Kathetostoma laeve*

Gnathagnus innotabilis is at once distinguished from the common Tasmanian uranoscopid *Kathetostoma laeve* (Block & Schneider, 1801) by its possession of scales (though these are inconspicuous) and of the remarkable mental processes that obscure all save a small elliptical area of the chin. Some other important differences may be noted. For typographical convenience the two forms are here denoted by *G.i.* and *K. l.* respectively.

G.i. has fewer dorsal rays (12-13 *cf.* 15-16): the pectoral count (19-21) stands wholly outside that (15-16) conventionally given, e.g. Scott *et al.* (1974) for *K.l.* but decidedly higher values for that species (18-20) have been reported in Part XX (1974b). A feature originally usefully employed by Waite & McCulloch (1915, p.471, figs 1,2; pl.13) in differentiating between *K.l.* and their *Kathetostoma nigrofasciatum* is the form of the naked basin-like interorbital region, and this criterion has since been extended to cover other species (Scott *et al.*, fig. on p.264, Mees 1960, fig.5). In *G.i.* the posterior border of this region lies in advance of level of posterior border of orbit, modally by about one-fourth eye diameter, in *K.l.* behind it by an eye diameter

or more; further, whereas in *G.i.* (& in *K. nigrofasciatum*) the orbit as defined by the well developed circumorbital ridge is complete, in *K.l.* it is interrupted at the posteroexternal angle by a small spur. In *G.i.* the occipital region presents a pair of conspicuous longitudinal ridges or elongated knobs set side by side with radiating from each a conspicuous series of short ridges; in *K.l.* this area wholly lacks these structures, having the form of a single flat or somewhat concave subquadrangular plate defined by low ridges. Circumoral cirri are absent in *G.i.* well developed and in *K.l.* (and in *K. gigantewm*).

In *G.i.* the ventral fins are inserted wholly on the ventral surface, so positioned that the outline of the body from the pectoral runs forward wholly externad of the fins, the lines of the right and left sides meeting at a tolerably sharp point; in *K.l.* the insertion of the ventral fins is in some measure lateral so that when normally disposed they obscure part of the body outline, while in advance of the fins the ventral surface tends to widen, with some straightening of the two sides, thus terminating anteriorly not in a triangle but in a truncated pyramid around the front of which the branchiostegal membranes make a broad slow curve (in specimens comparable in size with our largest *G.i.* there is here developed a platform the area of which exceeds that of the orbit). In *K.l.* two stout tolerably pungent forwardly directed spines, often embedded in the flesh, occur at the lateral borders of the prepelvic region; these are not present in *G.i.* and are a generic character of *Kathetostoma*. The lateral lines converge caudad less noticeably in *G.i.* in which the intervals between them at the levels of dorsal origin and dorsal termination are around 0.7 0.4 that at their anterior ends, the corresponding figures for *K.l.* being around 0.4 0.2. The presence in *G.i.* of the strong plectroid processes developed on either side of the chin leads to the anterior profile of the head in side view taking the form of a markedly convex curve; in *K.l.* it is not far from being rectilinear. In *G.i.* the length of the dorsal base is about one-fourth of the standard length and is modally less than the interval between the origin of the fin and the posterior border of the dorsal cephalic armour, in *K.l.* about one-third and modally equal to or greater than that interval. The large fan-shaped opercular plate with about a dozen ridges, ranging from moderate to strong, radiating from the upper angle that forms a conspicuous part of the armature in *G.i.* is in *K.l.* normally covered with skin, the whole region being smooth and superficially soft. In *K.l.* the eyes are wholly dorsal, in *G.i.* partly lateral. The color patterns are characteristic, the most obvious points of difference being the dorsal mottling on the body in *G.i.* and the dark subopercular dark blotch in *K.l.*

Comparison with other species of *Gnathagnus*

Three species of *Gnathagnus* Gill, 1861 are now recognized (Mees 1960): (a) *Uranoscopus elongatus* Temminck & Schlegel, 1843 (type species of *Gnathagnus* type locality, Japan) (b) *Gnathagnus innotabilis* Waite, 1904 (type locality, off Narrabeen, New South Wales) (c) *Benthoscopus laticeps* Longley & Hildebrand, 1940 (type species of *Benthoscopus* Longley & Hildebrand, 1940 type locality, off Tortugas, Florida). Species (c) has been clearly shown by Myers (1946) to belong to *Gnathagnus* with which its authors in proposing *Benthoscopus* did not compare it. In contrasting his species with *G. elongatus* as described by Jordan & Snyder (1902) Waite remarked 'In their generic diagnosis these authors write "humeral spine obsolete", yet describe the species as having a "partly concealed humeral spine"': the original account (Temminck & Schlegel 1843, p.27) stated clearly enough 'L'os de l'épaule sort de la peau en forme d'épine conique et un peu dirigée en haut'. It may be remarked in passing that while in his general description Waite characterized the spine as 'of moderate size, fully exposed' in some of our specimens a noticeable portion of it is embedded in flesh. Waite's statement 'there is a blunt prominence at the angle of the preopercle' would seem to imply, in the context in which it occurs, that this feature was not noticed by Jordan & Snyder: the original figure (pl.9, fig.2) appears to depict a largish bluntly rounded prominence at the angle. The plectroid mental dilatations of (b) are noted by Waite

as rounded, lacking the 'free pointed tip above' described and figured for (a): in our material the upper angle of the distal border while not produced into a distinct process is nevertheless in some individuals tolerably pointed. Some comparison of the three species was made by Myers in the paper in which he identified Longley & Hildebrand's fish as a member of the present genus. In the subjoined assessment the data for (a) and (c) are derived from the literature, without examination of specimens.

Teeth biserial in both jaws in (a) (b), in (c) stated to be 'in a single series in lower jaw' (Longley & Hildebrand 1940, p.266). The humeral spine in (a) and (b) has been discussed above; in (c) it is larger and more conspicuous, strongly curved upward. Dorsal with 12 rays in (b) 13 in (c) 14 in (a); fin base in (b) $\geq 3\frac{1}{2}$ in total length and about 1.5 in head measured from upper jaw, in (b) (c) ≤ 3 and about 1.0; lowest in (a) height about 3 in head length as before, in (b) (c) about 2. In (a) (c) ventral figured with spine well separated from adjoining ray, in (b) figured as closely apposed to ray but in our material bound up with it in common integument. Gill rakers on lower limb of anterior arch 14 in (c), in (b) not reported for type in our specimens $\geq$ 17. Pectoral in (a) strongly rounded in upper two-thirds partly straight and partly gently convex in lower one-third, in (b) figured much as in (a) but in our examples more or less squared off or somewhat concave in greater part of lower half, in (c) with upper and lower quarters convex middle half concave (outline quite an unusual one and highly characteristic). In the illustration of the upper surface of the head of (c) (fig.21) the two large occipital plates are asymmetric, partly separate, with the right well in advance of the left: in our material of (a) they are in full contact in the Tasmanian but not in the *Endeavour* examples and constitute a pair in respect both of form and of location. Chief elements of color pattern in (a) very numerous subequal ovoid spots about their own diameter apart ('parsemé de petites taches foncées, très nombreuses et très serrées'), in (b) indistinct brown spots present or absent, in (c) 'very many fine spots and dashes of olive scattered at random.' The line of about half a dozen small separate plates lying behind the large paired occipitals and extending out on either side towards the plate in the supratemporal region noted for (a) ('à la base de la crête occipitale, une rangée transversale d'assez petits') is in (b) for the most part contiguous with the posterior borders of the occipitals in the syntype and in the Tasmanian examples, but is clearly separate from them in the *Endeavour* fish; no plates are figured in this region in (c). The occurrence in (a) of naked regions between elements of the cranial armour is the subject of comment both in the description of type material ('ces plans sont en grande parte isolés, ils sont séparés les uns des outres par une peau nue, à surface lisse, laquelle est diversement coloriée que les plans-mêmes, qui sont par cette raison assez apparents') and in the diagnosis of *Gnathagnus* with (a) as type-species, 'Head with the osseous compartments of its superior surface mostly separated by smooth intervals' (Gill, 1861, p.115); in (b) the relative area of these would appear to be no greater than that found in, for instance, *Kathetostoma laeve* (indeed, if the operculum be included for comparison it is less), and the distinction in color between plates and the intervals between them while pronounced in the *Endeavour* specimens is in general barely evident in the others; in (c) as figured the naked area is proportionately somewhat larger than in (b).

TABLE 3

GNATHAGNUS INNOTABILIS WAITE, 1904

Dimensions of 8 specimens, (a) off Eddystone Point, east coast, Tasmania (b) off Narrabeen, New South Wales (one of three syntypes) (c) (d) (f) off Babel Island, Bass Strait (*Endeavour*) (e) (g) off southeast coast, Tasmania (h) off St Helens Point, east coast, Tasmania. First line in millimetres all other lines as thousandths of standard length.

Dimensions	(a)	(b)	(c)	(d)	(e)	(f)	(g)	(h)
Standard length	125	135	175	185	209	223	225	252
Total length	1 240	1 252	1 246	1 205	1 222	1 220	1 236	1 230
Length to origin of dorsal	648	578	623	605	603	628	609	619
Length to termination of dorsal	896	807	846	849	856	868	844	861
Length of longest dorsal ray	144	156	131	111	132	126	113	142
Length to origin of anal	584	541	526	573	555	561	560	556
Length to termination of anal	976	874	920	908	934	942	884	933
Length of longest anal ray	108	104	111	97	103	94	98	114
Length to origin of pectoral	320	282	286	292	301	287	298	298
Length of pectoral, whole fin	384	363	360	292	321	287	307	274
Length of longest pectoral ray	312	237	291	224	246	242	244	230
Length to origin of ventral	196	163	171	168	158	143	169	159
Length of ventral, whole fin	248	230	240	249	199	238	189	222
Length of longest ventral ray	208	193	205	175	175	169	169	173
Length to vent (middle)	544	526	537	535	536	525	529	536
Length of head	376	326	383	346	349	359	364	381
Length to base of humeral spine	352	319	366	357	330	363	351	345
Length of eye	64	60	69	64	63	63	58	56
Height of eye	62	52	68	57	48	58	57	48
Interorbital	138	127	126	114	117	120	112	115
Snout, from midpoint of front of upper jaw	42	52	45	38	46	45	47	40
Snout, from level of front of maxilla	72	65	57	59	74	67	63	56
Snout, from most advanced point (chin)	112	104	120	106	99	121	100	111
Depth at front of eye	204	152	154	146	158	148	151	143
Depth at back of eye	216	163	171	151	172	155	160	147
Depth at operculum	232	185	174	162	172	157	187	147
Depth at vent	208	143	154	146	172	157	187	151
Maximum depth of head	240	185	177	162	177	157	187	155
Maximum depth of body	232	200	171	162	170	152	191	151
Depth of caudal peduncle	72	74	80	76	83	72	71	73
Width at front of eye	276	252	229	205	215	206	196	206
Width at back of eye	328	307	286	254	258	247	236	254
Width at operculum	336	333	314	276	282	285	289	298
Width at vent	216	200	246	216	210	220	227	238
Maximum width of head	368	341	320	286	282	291	293	310
Maximum width of body	304	326	309	273	282	274	284	282

TABLE 4

GNATHAGNUS INNOTABILIS WAITE, 1904

$L = b\ N^k$ (rectified as $\log L = k \log L + \log b$) for 8 specimens; L = {length of head, length to vent, length to caudal origin, expressed as thousandths of standard length}, N = {1,2,7}.

Specimen	Standard length mm	Slope (k)	Intercept ($\log b$)	t	Measured (predicted) lengths
(a)	125	0.4884	2.5909	23.250*	384(390) 560(547) 1 000(1 008)
(b)	135	0.5684	2.5276	11.696	326(337) 526(500) 1 000(1 018)
(c)	175	0.4936	2.5825	211.416**	383(382) 537(538) 1 000(999)
(d)	185	0.5399	2.5496	16.182*	346(354) 535(515) 1 000(1 013)
(e)	209	0.5358	2.5526	17.160*	349(357) 536(518) 1 000(1 013)
(f)	223	0.5250	2.5578	17.557*	359(361) 525(520) 1 000 (1 024)
(g)	225	0.5190	2.5636	64.730*	364(366) 529(524) 1 000(1 003)
(h)	252	0.4961	2.5805	359.221**	381(381) 536(537) 1 000(999)
G.M.	187.2	0.5206	2.5631	28.826*	361(366) 536(525) 1 000(1 007)

FAMILY TETRAODONTIDAE

The members of this family appearing in the earlier local lists (Johnston 1883, 1891) under the broad category Gymnodontes are in the later catalogues (Lord 1923, 1927, Lord & Scott 1924) referred to Tetraodontidae, a course followed by the majority of Australian authors though some, *e.g.*, Whitley (1968), adopt Lagocephalidae, a taxon Greenwood *et al.* (1966) in their provisional classification of living teleosts recommend subsuming in Tetraodontidae. Part XI of this series (1963) provided a key to the four species then known from our waters — *Tetraodon armilla* McCulloch & Waite, 1915 (referred by Whitley (1964) in his definitive Australian name-list to his genus *Omegaphora*, 1934), *Sphaeroides hamiltoni* (Gray & Richardson, 1843) (in Whitley's name-list placed *Aphanacanthus* Troshchel, (1856), *Sphaeroides richei* (Freminville) (now often referred to *Contusus* Whitley, 1947). *Sphaeroides liosomus* Regan, 1909 (now generally regarded as a junior synonym of *Gastrophysus glaber* Freminville, 1813).

Since the appearance of Part XI two species have been added to the local list, *Boesemanichthys firmamentum* (Temminck & Schlegel, 1850), recorded in Part XIII (1965), being there referred to the genus *Tetraodon*, and *Lagocephalus lagocephalus* (Linne, 1758), first Tasmanian (and Australian) record by Andrews (1970). The latter differs trenchantly from the species keyed in Part XI in having on each side two nostrils instead of one or a pair of flaps without an aperture (*Lagocephalus* accommodated by some writers in a separate family Lagocephalidae, the nares diagnostic). *Boesemanichthys firmamentum* is readily separable from the keyed species by its large number of dorsal and anal rays, 14 in each fin, a maximum of 9-11 being found in the other species.

TABLE 5

GNATHAGNUS INNOTABILIS WAITE, 1904

Head in plan: $W = A + BN - CN^2$ calculated for 8 individuals from 10 measurements (N) of width taken at equal intervals between most advanced point and level of opercular border at visual ventral plane, widths expressed as percentages of relevant anteroposterior length.

Specimen	*Ls*, mm	A	B	C	*R*	Tangent	Measured (predicted) widths
(a)	125	50.19	16.530	1.1064	0.9993	2.2129	65.1(65.6) 79.5(78.8) 89.3(89.8) 99.3(98.6) 105.6(105.2) 109.5 (109.5) 110.5(111.7) 111.6(111.6) 109.8 (109.3) 104.9(104.9)
(b)	135	42.31	13.917	0.9828	0.8646	1.9656	54.6(55.3) 67.1(66.2) 75.0(74.2) 81.5(82.2) 88.5(87.3) 91.0(91.4) 90.4(91.6) 89.8(90.7) 88.5(87.9) 83.3(83.2)
(c)	175	27.12	16.246	0.9814	0.9972	1.9629	40.8(42.4) 58.1(55.9) 67.5(67.0) 75.5(76.4) 83.1(83.8) 89.4(89.3) 92.3(92.7) 94.2(94.3) 95.1(93.8) 90.8(91.4)
(d)	185	31.65	14.334	0.8769	0.9955	1.7537	42.9(45.1) 60.3(56.8) 66.7(69.8) 74.1(75.0) 81.0(82.4) 85.9(86.1) 88.9(88.7) 90.5(90.2) 89.7(89.6) 87.3(87.3)
(e)	209	31.99	14.935	0.9379	0.9989	1.8758	46.7(46.0) 58.0(58.1) 67.3(68.4) 76.4(76.7) 82.7(83.2) 89.5(87.8) 90.7(90.6) 91.2(91.5) 90.5(90.4) 87.3(87.6)
(f)	223	32.98	12.915	0.7398	0.9983	1.4795	45.0(45.2) 56.5(55.8) 64.5(65.1) 72.6(72.8) 78.9(79.1) 84.9(83.8) 86.3(87.1) 88.8(89.0) 90.0(89.2) 87.8(88.2)
(g)	225	29.38	12.280	0.6265	0.9779	1.2530	40.0(41.0) 53.3(51.4) 60.5(60.6) 68.1(68.5) 75.0(75.1) 79.8(80.7) 83.8(84.6) 88.0(87.5) 91.4(89.2) 88.1(89.5)
(h)	252	19.86	17.167	1.0481	0.9883	2.0962	34.7(36.0) 51.3(50.0) 63.0(61.9) 71.7(71.8) 78.4(79.5) 84.6(85.1) 89.1(88.7) 90.3(90.1) 89.1(90.0) 87.0(85.7)

TABLE 6

GNATHAGNUS INNOTABILIS WAITE, 1904

Disposition of fins along anteroposterior axis of fish: specifications for 8 specimens, standard length, *Ls*, 125-252 mm, of the relation $L = b\ N^k$ (rectified as $\log L = k \log N + \log b$) where L = {length to pectoral origin, anal origin, dorsal origin, dorsal termination, anal termination, caudal origin}, N = {1, 3, 4, 7, 8, 10}.

Specimen	*Ls*, mm	*k* (slope)	log *b* (intercept)	*t*	Measured (predicted) lengths as thousandths of *Ls*
(a)	125	0.5119	2.5109	25.678*	320(324) 584(569) 648(659) 896(878) 976(940) 1 000(1 054)
(b)	135	0.5423	2.4529	31.377*	281(284) 541(515) 578(602) 807(816) 874(886) 1 000(989)
(c)	175	0.5522	2.4581	67.376*	286(287) 526(527) 623(617) 846(841) 920(925) 1 000(1 024)
(d)	185	0.5335	2.4750	25.423*	292(299) 573(537) 605(626) 849(843) 908(905) 1 000(1 020)
(e)	209	0.5279	2.4799	26.406*	301(302) 555(539) 603(603) 856(843) 921(905) 1 000(1 018)
(f)	223	05510	2.4680	30.724*	287(294) 561(538) 628(631) 868(858) 942(924) 1 000(1 045)
(g)	225	0.5220	2.4803	36.743*	298(302) 560(536) 609(623) 844(835) 884(895) 1 000(1 005)
(h)	252	0.5332	2.4784	23.221*	298(301) 556(540) 619(630) 861(849) 925(912) 1 000(1 027)
G.M.	187.2	0.5308	2.4786	43.507*	298(301) 557(539) 617(628) 853(846) 918(908) 1 000(1 022)

Genus *BOESEMANICHTHYS* Abe, 1952

Boesemanichthys Abe, 1952, *Jap. Journ. Ichth.*, 2(1), p.40. Type-species, *Tetraodon firmamentum* Temminck & Schlegel, 1850.

Boesemanichthys firmamentum (Temminck & Schlegel, 1850)

Tetraodon firmamentum Temminck & Schlegel, 1850, FAUN. JAP. POISS., p.280, pl.126, fig.2. Type-locality: Japan.

? Tetraodon gillsbanksii Clarke, 1897, *Trans. N.Z. Inst.*, 29, pp.244, 245, pl.14. Type-locality: Moturoa, Taranaki.

Boesemanichthys firmamentum: Whitley, 1964, *Proc. Linn. Soc. N.S.W.*, 89(1), p.59.

Additional material

This rather rare wide-ranging deepwater species, recorded in the Check-List (McCulloch 1929) from Japan (type-locality), New South Wales, Victoria New Zealand (the last-named presumably on the basis of *Tetraodon gillsbankii* Clarke, 1897, treated in the Australian Check-List as a synonym, but accepted in the New Zealand Check-List (Whitley 1968) as a valid species) was first recorded for this State in Part XIII (1965) on the basis of an example, *Ls* 237 *Lt* 302, found washed up on the sand after a storm at Greens Beach, north coast, in July 1961. Two additional examples, *Ls* 240 246 *Lt* 301 302, are here noted, both taken off Eddystone Point, east coast, in April 1979 by Mr Shane Down.

TABLE 7

GNATHAGNUS INNOTABILIS WAITE, 1904

Ventral fin, 8 specimens, $L = b\ N^{*k}$ (rectified as $\log L = k \log N^* + \log b$) where L = {length of spine, 5th 4th 3rd 2nd ray, as thousandths of standard length} {1st ray that farthest from spine}, N^* = {1 2 3 4 5}.

Specimen	Standard Length mm	Slope k	Intercept $\log b$	t	Measured (predicted) lengths
(a)	125	0.6518	1.8636	30.885***	72(73) 116(115) 152(149) 184(180) 202(208)
(b)	135	0.8339	1.7691	14.004***	56(59) 111(105) 156(147) 190(187) 207(225)
(c)	175	0.7865	1.7911	18.418***	61(62) 108(107) 149(147) 194(184) 206(219)
(d)	185	0.7970	1.7396	23.626***	54(55) 97(95) 130(132) 175(166) 189(198)
(e)	209	0.7578	1.7580	35.737***	57(57) 96(97) 132(132) 170(164) 189(194)
(f)	223	0.9102	1.6702	28.733***	45(47) 92(88) 130(127) 166(165) 195(202)
(g)	225	0.8536	1.6573	22.749***	44(45) 85(82) 118(116) 153(148) 170(179)
(h)	252	0.7579	1.7233	22.492***	52(53) 93(89) 121(122) 157(151) 171(181)
G.M.	186.2	0.7936	1.7465	25.219***	54(56) 99(97) 135(133) 173(168) 191(200)

Dimensions as *TLs*

The principal dimensions as millesimals of standard length (smaller present individual first, earlier specimen last entry) follow. Length to origin termination of dorsal 742 732 779 829 833 868, of anal 788 776 826 879 870 894. Lengh to origin of pectoral 325 346 345, length of fin 163 165 143. Length to vent (middle) 742 732 740. Head to front of gill slit 296 313 323, to back of slit 317 333 333. Snout 108 126 115. Eye 54 69 51. Interorbital 146 175 187. Length of longest of last ray of dorsal 192 46, 183 45, 194 46, of anal 200 46, 185 45, 194 57. Depth at front of eye 200 203 203, at back of eye 217 248 262, at gill slit 277 362 359, at vent 242 244 257; maximum depth 313 386 367; depth of caudal peduncle 100 100 105.

Meristic characters

D.14. A.14. P.16.15 17. C. main rays 1 + 7 + 1.

Coloration, spinulation

As was the case with the 1965 specimen the general coloration is in good broad agreement with that of the original figure, reproduced by McCulloch (1922, pl.58, fig. 369f). Chief differences: in both individuals demarcation between upper dark and lower light regions much less definite; lighter area less extensive, extending in larger fish only about halfway from ventral profile to level of pectoral, in smaller reaching obscurely to somewhat below that fin; hinder part of caudal dusky in part blackish; in smaller fish light spots on caudal fewer smaller less well defined, in one subvertical row only.

The nature of the spines and their pattern of distribution are similar to those described in Part XIII (1965).

Some aspects of form

(a) *Head, length to vent, standard length.* On a loglog grid these three lengths are significantly linear for both individuals (*t* 23.309* 52.884*) and for the earlier example (*t* 41.635*) — measurements of which were not given in Part XIII but have now been made — on 1 5 10.

Dimensions below as *TLs*, 1965 specimen last.

Log *L* = 0.5041 log *N* + 2.5050. Measured (predicted) lengths 317(320) 742(720) 1 000(1 021).

Log *L* = 0.4796 log *N* + 2.5242. Lengths 333(334) 732(723) 1 000(1 008).

Log *L* = 0.4706 log *N* + 2.5340. Lengths 340(342) 740(729) 1 000(1 011).

Among a large number of species representative of a wide range of families in which this head, pre-vent, precaudal relationship has been investigated abscissal values in the loglog formulation of 1 5 10 are exceptional (modal set 1 2 3, followed in frequency by 2 3 4). To arrive at some general provisional idea of the general situation in this family, regression equations have been calculated for some species noted in earlier contributions in this series, namely, in Part XI (1963), 8 specimens of *Contusus richei*, *Ls* 74-125 (table 5, species there referred to *Sphaeroides*), in same table 1 specimen of *Sphaeroides hamiltoni*, *Ls* 78, and in Part XVIII (1971) 1 specimen, *Ls* 78, of *Tetraodon armilla* (dimensions of beach example reported in Part XI not recorded).

For *Contusus richei* the abscissal set is, as in the present species, 1 5 10, the *t* values ranging from 20.930* to 211.568**, mean 102.373**, with 6 of the 8 significances being better than P 0.01. For *Sphaeroides hamiltoni* the best straight line (*t* 43.865*) has the abscissal set 1 7 10, while the set for *Tetraodon armilla* is 1 6 10.

(b) *Disposition of fin origins and terminations.* On a loglog grid the lengths to pectoral origin dorsal origin anal origin dorsal termination anal termination caudal origin (*Ls*) are highly significantly linear (*t* 38.360*** 28.058*** 11.624***) on 1 5 6 7 8 10. Dimensions below as *TLs*, 1965 specimen last.

Log *L* = 0.4846 log *N* + 2.5156. Measured (predicted) lengths 325(328) 742(715) 788(781) 829(841) 879(898) 1 000(1 010).

Log *L* = 0.4534 log *N* + 2.5396. Lengths 346(346) 732(719) 778(781) 833(837) 870(889) 1 000(984).

Log *L* = 0.4655 log *N* + 2.5477. Lengths 345(353) 779(741) 826(807) 868(867) 894 (923) 1 000(1 024).

It is of interest to note the same 1 5 6 7 8 10 formulation (covering in the absence of ventral in these fishes all the fins) is applicable to the 1971 example of *Tetraodon armilla* noticed above (*t* 24.145***).

Log *L* = 0.4045 log *N* + 2.5852. Lengths 383(384) 765(738) 790(794) 840(845) 854(892) 1 000(998).

REFERENCES

Allen, G.R., Hoese, D.F., Paxton, J.R., Randall, J.E., Russell, B.C., Stark, W.A.II, Talbot, F.H. and Whitley, G.P. 1976: Annotated checklist of the fishes of Lord Howe Island. *Rec. Aust. Mus.*, 30(15) (Ophichthyidae, D.H. Hoese: 378-379).

Andrews, A.P., 1970: A record of the oceanic puffer *Lagocephalus lagocephalus* (L.), order Tetraodontoidea, from King Island, Tasmania, *Pap. Proc. R. Soc. Tasm.*, 104: 111-112, pl.1.

_____, 1971: A catalogue of the type material (Fishes) in the Tasmanian Museum. *Pap. Proc. R. Soc. Tasm.*, 105: 1-3.

Anon., 1956: (Report of xanthic eel from Victoria). *Anglers' Digest and Shooters' Monthly*, Oct. 1956.

Bloch, M.E. and Schneider, J.G., 1801: SYSTEMA ICHTHYOLOGIAE. Sanderiano. Berlin.

Castelnau, F.N., 1872: Contribution to the ichthyology of Australia. No. 1. The Melbourne fish market. *Proc. zool. acclim. Soc. Vict.*, 1: 29-242, one pl.

_____, 1875: Researches on the fishes of Australia. Intercolonial Exhibition essays. No. 2: 1-52. PHILADELPHIA CENTENNIAL EXHIBITION, 1876 (MELBOURNE, 1875): OFFICIAL RECORD.

Dawson, C.E., 1977: Review of the Indo-Pacific pipefish genus *Lissocampus* (Syngnathidae). *Proc. biol. Soc. Wash.*, 89(53): 599-620, figs 1-7.

Garman, S., 1913: The Plagiostomia. *Mem. Mus. comp. Zool. Harvard*, 36: 1-528, pls 1-77.

Gill, T., 1861: Synopsis of the Uranoscopoids. *Proc. Acad. nat. Sci. Philad:* 108-117.

Greenwood, P.H., Rosen, D.L., Weitzman, S.H. and Myers, G.S., 1966: Phyletic studies of teleostean fishes with a provisional classification of living forms. *Bull. U.S. Mus. nat. Hist.*, 131(4).

Günther, A., 1859: CATALOGUE OF THE ACANTHOPTERYGIAN FISHES IN THE COLLECTION OF THE BRITISH MUSEUM, 1. British Museum, London.

_____, 1860: CATALOGUE OF THE ACANTHOPTERYGIAN FISHES IN THE COLLECTION OF THE BRITISH MUSEUM, 2. British Museum, London.

Haast, J., 1873: On some undescribed fishes of New Zealand. *Trans. N.Z. Inst.*, 5: 272-278, pl.16.

Haysom, N.H., 1960: (Xanthic fish). *Qld Fisher. inform. Bull.*, 17: 2.

Hutton, F.W., 1872: Catalogue with diagnoses of the species. FISHES OF NEW ZEALAND: 1-93.

Johnston, R.M., 1883: General and critical observations on the fishes of Tasmania; with a classified catalogue of all known species. *Pap. Proc. R. Soc. Tasm.* (1882): 54-144.

_____, 1885: Description of a new species of *Odax*. *Pap. Proc. R. Soc. Tasm.* (1884): 231-232.

_____, 1891: Further observations on the fishes and fishing industries of Tasmania, together with a revised list of indigenous species. *Pap. Proc. R. Soc. Tasm.* (1890): 22-46.

Jordan, D.S. and Snyder, J.O., 1902: A review of the trachinoid fishes and their supposed allies found in the waters of Japan. *Proc. U.S. nat. Mus.*, 24: 229-256.

Kershaw, J.A., 1904: A colour variety of the common eel, *Anguilla australia* Rich. *Vict. Nat.*, 20(10), 242: 129-140.

Ling Roth, H., 1899: THE ABORIGINES OF TASMANIA; 2nd ed.F. King and Sons, Halifax, England. (Facsimile reissue, n.d. = 1969, Fullers Bookshop, Hobart).

Longley, W.H. and Hildebrand, S.F., 1940: New genera and species of fishes from Tortugas, Florida. *Pap. Tortugas Lab.*, 5(32) (Carnegie Institute publication No.,517): 223-285.

Lord, C.E., 1923: A list of the fishes of Tasmania. *Pap. Proc. R. Soc. Tasm.* (1922): 60-73.

_____, 1927: A list of the fishes of Tasmania. *J. pan-Pac. res. Inst.*, 2(4): 11-16.

Lord, C.E. and Scott, H.H., 1924: A SYNOPSIS OF THE VERTEBRATE ANIMALS OF TASMANIA. Oldham Beddome and Meredith, Hobart.

Lucas, A.H.S., 1890: A systematic census of indigenous fishes hitherto reported from Victoria. *Proc. R. Soc. Vict.* (n.s.), 2: 15-47.

McCulloch, A.R., 1911: Report on the fishes obtained by the F.I.S. 'Endeavour' on the coasts of New South Wales, Victoria, South Australia and Tasmania. Part 1. *Zool. res. Endeavour*, 1(1): 1-87, pls 1-16, figs 1-19.

_____, 1914: Notes on some Australian pipe-fishes. *Aust. Zool.*, 1(1): 29-31, figs 1-4.

_____; 1916: Ichthyological items. *Mem. Qld Mus.*, 5: 58-69, pls 7-9, figs 1-4.

_____, 1921: Check-list of the fishes and fish-like animals of New South Wales. Part 2. *Aust. Zool.*, 2(2): 14-58, pls 4-24.

_____, 1922: Check-list of the fishes and fish-like animals of New South Wales. Part 3. *Aust. Zool.* 2(3): 86-130, pls 25-43.

_____, 1929: A check-list of the fishes recorded from Australia. *Aust. Mus. Mem.*, 5(1-4) (part 4, index, 1930): i-ix + 1-534.

McKay, R.J., 1966: Studies on Western Australian sharks and rays of the families Scyliorhinidae, Urolophidae and Torpedinidae. *J. R. Soc. W. Aust.*, 49(3): 65-82, figs 1-6.

Marshall T.C., 1964 : FISHES OF THE GREAT BARRIER REEF AND THE COASTAL WATERS OF QUEENSLAND. Angus & Robertson, Sydney.

Mees, G.F., 1960: The Uranoscopidae of Western Australia (Pisces, Perciformes). *J. R. Soc. W. Aust.*, 43(2): 46-58, figs 1-9.

Munro, I.S.R., 1956: Handbook of Australian fishes, 1: 1-8. *In: Fisher. Newsl.* (now *Aust. Fisher.*), 15(7).

_____, 1957a: Handbook of Australian fishes, 11: 45-48. *In: Fisher. Newsl.* (now *Aust. Fisher.*), 16(5).

_____, 1957b: Handbook of Australian fishes, 17: 69-72. *In. Fisher. Newsl.* (now *Aust. Fisher.*), 16(11).

_____, 1958: Handbook of Australian fishes, 21: 85-88. *In: Fisher. Newsl.* (now *Aust. Fisher.*), 17(3).

_____, 1967: THE FISHES OF NEW GUINEA. Department of Agriculture, Stock and Fisheries, Port Moresby.

Myers, G.S., 1946: Occurrence of uranoscopid fishes of the Western Pacific genus *Gnathagnus* in the American Atlantic fauna. *Copeia*, 1946, 1: 42.

Neave, S.A., 1940(+): NOMENCLATOR ZOOLOGICUS. A LIST OF THE NAMES OF GENERA AND SUBGENERA IN ZOOLOGY FROM THE TENTH EDITION OF LINNAEUS 1758 TO THE END OF 1935. Zoological Society, London.

Norman, J.R., 1934: A SYSTEMATIC MONOGRAPH OF THE FLATFISHES (HETEROSOMATA), VOL.1: PSETTODIDAE, BOTHIDAE, PLEURONECTIDAE. British Museum, London.

Ogilby, J.D., 1897a: Some Tasmanian fishes. *Pap. Proc. R. Soc. Tasm.* (1896): 69-85.

_____, 1897b: On a larval teleost from New South Wales. *Proc. Linn. Soc. N.S.W.*, 22(1): 158-160, fig. 1.

_____, 1916: Check-list of the Cephalochordates, Selachians and Fishes of Queensland. *Mem. Qld Mus.*, 5: 70-98, fig.1.

Olsen, A.M., 1958: New fish records and notes on uncommon Tasmanian species. *Pap. Proc. R. Soc. Tasm.*, 92: 155-159.

Plomley, N.J.B., 1976: A WORD-LIST OF THE TASMANIAN ABORIGINAL LANGUAGE. Launceston, author in association with Tasmanian Government.

Phillipps, W.J., 1927: Bibliography of New Zealand fishes. *N.Z. Mar. Dept. Fisher. Bull.* 1: 1-68.

Schmidt, E.J., 1928: The fresh-water eels of Australia. With some remarks on the short-finned species of *Anguilla*. *Rec. Aust. Mus.*, 16(4): 179-210, figs 1-14.

Schultz, L.P., 1953: Family Ophichthyidae: 45-60, figs 10-12. *In*: Schultz *et al.*, Fishes of the Marshall and Marianas Islands. Vol.1. (Asymmetrontidae through Siganidae). *U.S. Nat. Mus. Bull.* 202.

Scott, E.O.G., 1934-1979: Observations on some Tasmanian fishes. Parts I-XXV; in this journal (except Part XVI, 1969, *Aust. Zool.*, 15(2): 160-177, figs 1, 2). Contributions here cited. 1936, III: 113-129, figs 1-3. 1942b, V: 45-54, pl.7. 1953, VI: 141-166, figs 1-4. 1957, VIII: 145-156. 1961, X: 49-65, figs 1-3. 1963, XI: 1-29, figs 1, 8. 1964, XII: 85-106, fig.1. 1965, XIII: 53-65, fig.1. 1966, XIV: 93-115, fig.1. 1971, XVIII: 119-143, fig.1. 1974a, XIX: 247-292, figs 1,2. 1974b, XX: 171-197, figs 1-4. 1975, XXI: 127-175, figs. 1,2. 1976, XXII: 157-217, pl.1. 1977, XXIII: 111-180, figs 1-3. 1978, XXIV: 289-356, figs 1-3. 1979, XXV: 99-148.

_____, 1942a: *Syngnathus tuckeri, sp. nov.*: a new Tasmanian pipefish. *Rec. Queen Vict. Mus.*, 1(1): 17-20, pl.5.

_____, 1968: First Tasmanian record of the long-snouted pipefish. *Tasm. Fisher. Res.*, 2(2): 4-7.

Scott, J.K., 1976: A review of the fish genus *Neoodax* of Western Australia with description of a closely allied new genus and species. *Rec. W. Aust. Mus.*, 4(4): 349-373, figs 1-6.

Scott, T.D., 1962: THE MARINE AND FRESH WATER FISHES OF SOUTH AUSTRALIA. Government Printer, Adelaide.

Scott, T.D., Glover, C.J.M. and Southcott, R.V., 1974: THE MARINE AND FRESHWATER FISHES OF SOUTH AUSTRALIA. Government Printer, Adelaide.

Stead, D.G., 1963: RAYS AND SHARKS OF AUSTRALIAN SEAS. Angus & Robertson, Sydney.

Temminck, J.C. and Schlegel, H., 1842: Pisces. *In*: Siebold's FAUNA JAPONICA. Leyde.

Waite, E.R., 1899: Scientific results of the trawling expedition of H.M.C.S. 'Thetis'. Introduction and Fishes. *Aust. Mus. Mem.*, 4(1): 1-132, frontispiece, pls 1-31.

_____, 1904: New records or recurrences of rare fishes from eastern Australia. No. 3. *Rec. Aust. Mus.*, 5(4): 231-244, pls 25,26, figs 33,34.

_____, 1907: A basic list of the fishes of New Zealand. *Rec. Canterb. Mus.*, 1(1): 3-39.

_____, 1911: Scientific results of the New Zealand Government trawling expedition, 1907. Pisces, Part 2. *Rec. Canterb. Mus.*, 1(3): 157-272, pls 24-57, figs 1-3.

Waite, E.R. and McCulloch, A.R., 1915: The fishes of the South Australian Government trawling cruise, 1914. *Trans. R. Soc. S. Aust.*, 39: 455-476, fig.1.

Weber, M. and De Beaufort, L.F., 1929: THE FISHES OF THE INDO-AUSTRALIAN ARCHIPELAGO, 5. J.S. Brill, Leiden.

Whitley, G.P., 1928: Studied in ichthyology. No. 2. *Rec. Aust. Mus.*, 9(3): 211-239, pls 16-28, figs 1,2.

_____, 1929a: R.M. Johnston's memoranda relating to the fishes of Tasmania. *Pap. Proc. R. Soc. Tasm.* (1928): 46-68, pls 2-4.

_____, 1929b: Additions to the check-list of the fishes of New South Wales. *Aust. Zool.*, 5(4): 353-357.

_____, 1939: Taxonomic notes on sharks and rays. *Aust. Zool.*, 9(3): 227-262, pls 20-22, figs 1-18.

_____, 1940: THE FISHES OF AUSTRALIA PART 1. THE SHARKS, RAYS, DEVIL-FISH, AND OTHER PRIMITIVE FISHES OF AUSTRALIA AND NEW ZEALAND. Royal Zoological Society of New South Wales, Sydney.

_____, 1943a: Ichthyological notes and illustrations. (Part 2). *Aust. Zool.*, 10(2): 167-187, figs 1-10.

_____, 1943b: Ichthyological descriptions and notes. *Proc. Linn. Soc. N.S.W.*, 68: 114-144, figs 1-12.

_____, 1943c: A new Australian shark. *Rec. S. Aust. Mus.*, 7(4): 397-399.

_____, 1944: New sharks and fishes from Western Australia. *Aust. Zool.*, 10(3): 252-273, figs 1-6.

_____, 1948: New sharks and fishes from Western Australia. Part 4. *Aust. Zool.*, 11(4): 259-276, pls 24,25, figs 1-7.

_____, 1950: Studies in Ichthyology. No. 14. *Rec. Aust. Mus.* 22(3): 234-245, pl. 17, figs 1-5.

Whitley, G.P., 1951: New fish names and records. *Proc. R. zool. Soc. N.S.W.*, 1949/50: 61-68, figs 8-10.

_____, 1952: Some noteworthy fishes from eastern Australia. *Proc. R. Zool. Soc. N.S.W.*, 1950/51: 27-32, figs 1-5.

_____, 1962: MARINE FISHES OF AUSTRALIA, 2 vols. Jacaranda Press, Brisbane.

_____, 1964: A survey of Australian Ichthyology. Presidential address. *Proc. Linn. Soc. N.S.W.*, 89(1): 11-127. Appendix A: Subject index: 20-32. Appendix B: Name-list of the fishes recorded from Australia: 32-60.

_____, 1967: Sharks of the Australasian region. *Aust. Zool.*. 14(2): 173-187, pl.4, figs 1;2.

_____, 1968: A check-list of the fishes recorded from the New Zealand region. *Aust. Zool.*, 15(1): 1-102, figs 1,2.

Whitley, G.P. and Phillipps, W.J., 1939: Descriptive notes on some New Zealand fishes. *Trans. R. Soc. N.Z.*, 69(2): 228-236, pls 21,22.

Papers and Proceedings of the Royal Society of Tasmania, Volume 114, 1980.

(ms. received 9.3.1978)

EARLY TRIASSIC OSTEICHTHYANS FROM THE KNOCKLOFTY FORMATION OF TASMANIA

by Thomas John Dziewa
Department of Biology, Wayne State University Detroit, Michigan 48202, U.S.A.

(with four text figures and eight plates)

ABSTRACT

DZIEWA, T.J., 1980 (31 v): Early Triassic osteichthyans from the Knocklofty Formation of Tasmania. *Pap. Proc. R. Soc. Tasm.*, 114: 145-160 (incl. 8 plates).ISSN 0080-4703. Department of Biology, Wayne State University, Detroit, Michigan, U.S.A.

A small but diverse osteichthyan assemblage from the freshwater deposits of the Early Triassic Knocklofty Formation of southeastern Tasmania is described. This includes *Ceratodus gypsatus*, Quenstedt, a coelacanthid, *Acrolepis hamiltoni* Johnston and Morton, *Acrolepis tasmanicus* Johnston and Morton, *Cleithrolepis granulata* Egerton, *Saurichthys* sp. of which only the *Acrolepis* spp. had been previously recorded from this area, and an undetermined coulacante. Previously only had been reported from this locality.

INTRODUCTION

Osteichthyan remains collected from the Early Triassic Knocklofty Formation of southeastern Tasmania are described here.

The occurrence of osteichthyan remains from the fresh-water sediments of the Early Triassic Knocklofty Formation of southeastern Tasmania has been recognized since Johnston and Morton (1890, 1891) described *Acrolepis tasmanicus* from the Tinder Box Bay area. Little else was reported prior to the work of Cosgriff (1974). Material acquired by Cosgriff and the present author in 1971 during a collecting trip, generously sponsored by the National Geographic Society, and in earlier collections by Cosgriff, are forms assignable to the ubiquitous Triassic dipnoan genus *Ceratodus* as well as fragmentary remains assignable to the chondrostean genera *Saurichthys* and *Cleithrolepis*, and, questionably, the family Coelacanthidae.

Unfortunately, the new osteichthyan materials are of little stratigraphic use as, without exception, all of the genera present have a relatively long geologic time range. The evidence provided by the amphibian and reptilian remains, is at present far more reliable for purposes of correlation (Cosgriff 1974).

Fish-bearing localities in the Knocklofty Formation

(Figs 1-2)

1. Old Beach locality:- Derwent (1:100 000); metric coordinates: 8312-238623
Fauna. *Ceratodus gypsatus*
Acrolepis sp.
Lithology. Clay-pebble conglomerate matrix collected from a lenticular stream channel deposit.
Stratigraphy. The stratigraphic position of this site is generally equivalent to the lower member of the section of the Knocklofty Formation exposed at Crisp and Gunn Quarry (Cosgriff 1974).
2. Midway Point locality:- Prosser (1:100 000); 8412-427617
Fauna. *Ceratodus gypsatus*
Coelacanthidae gen. et sp. indet.

Lithology. Clay-pebble conglomerate matrix collected from lenticular stream channel deposits.

Stratigraphy. The stratigraphic position of this site relative to the section of the Knocklofty Formation exposed at Crisp and Gunn Quarry is not known (Cosgriff, 1974)

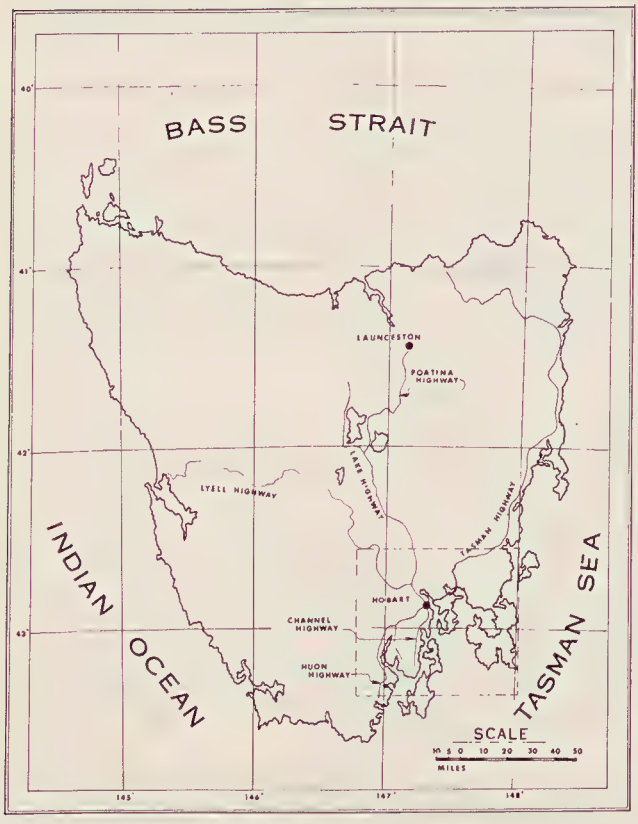


FIG. 1. - Tasmania, showing principal cities and highways. (The area enclosed within the dash-bordered box is shown enlarged and with more detail in Figure 2.)

3. Granton locality:- Derwent (1:100 000); 8312-200649.

Fauna. Osteichthyan of indeterminate taxonomic affinity.

Lithology. Gray siltstone.

Stratigraphy. The stratigraphic position of this site relative to the section of the Knocklofty Formation exposed at Crisp and Gunn Quarry is not known.

4. Tinderbox Bay locality:- D'Entrecasteaux (1:100 000):- 8311-266325.

Fauna. *Acrolepis tasmanicus*

Lithology. Sandstone

Stratigraphy. The stratigraphic position of this site relative to the section of the Knocklofty Formation exposed at Crisp and Gunn Quarry is not known.

5. Coningham locality:- D'Entrecasteaux (1:100 000); 8311-236301

Fauna. *Ceratodus gypsatus*
Cleithrolepis granulata
Saurichthys sp.

Lithology. Clay-pebble conglomerate matrix collected from several lenticular stream channel deposits.

Stratigraphy. While not definitely established, the varied lithology of the section of this site suggests that it is equivalent to the middle member of the formation of Knocklofty (Cosgriff 1974).

6. Cascade locality:- Derwent (1:100 000); 8312-244507.

Fauna. *Acrolepis hamiltoni*

Lithology. Sandstone.

Stratigraphy. The stratigraphic position of this site relative to the section of the Knocklofty Formation exposed at Crisp and Gunn Quarry is not known.

FIG. 2. - Southeastern Tasmania, the areas of outcrop of the Knocklofty Formation and the principal vertebrate localities from which fossil fish have been recovered:
(A) Derwent estuary; (B) Pitt water; (C) Derwent River;
(D) Huon River;
1. Old Beach locality; 2. Midway Point locality; 3. Granton locality;
4. Tinderbox Bay locality; 5. Coningham locality; 6. Cascades locality.
The coastlines and the areas of outcrop of the Knocklofty Formation (shown in cross hatch) are based on The Geological Map of Tasmania, Geological Survey, Department of Mines, Tasmania, 1961.

Class OSTEICHTHYES
Subclass SARCOPTERYGII
Order DIPNOI
Family CERATODONTIDAE Gill, 1872

Genus *CERATODUS* Agassiz, 1838

Diagnosis: See Woodward (1891, pp. 264-265)
Type species: *Ceratodus latissimus* Agassiz, 1838

Ceratodus gypsatus Quenstedt, 1885
(Fig. 3)

1885 *Ceratodus gypsatus* Quenstedt: 287, pl. 24, fig. 2
1909 *Ceratodus ornatus* Broom: 253-254, pl. 12, fig. 4 (new synonymy)
1924 *Ceratodus palaeoruncinatus* Frentzen: 216-220 (new synonymy)
1928 *Ceratodus palaeoruncinatus* Frentzen: Schmidt: 347, fig. 971
1974 *Ceratodus sp.* Cosgriff: 3

Referred Material

U.T.G.D. 87871, nearly complete left palatal dental plate lacking only the distal portion of the first ridge. U.T.G.D. 95100, nearly complete left mandibular dental plate lacking the distal tips of all four ridges. Both the above have been prepared out of a clay-pebble conglomerate matrix.

Also present in the collection are two incomplete dental plates U.T.G.D. numbers 95101, and 95102 contained in a clay-pebble conglomerate matrix.

The abbreviation U.T.G.D. indicates a specimen in the collection of the Geology Department, University of Tasmania; subsequently the abbreviation T.M. will be used for specimens in the collection of the Tasmanian Museum and Art Gallery.

Locality

U.T.G.D. 87871 from the Midway Point locality, number 95100 from the Coningham locality and numbers 95191 and 19102 from the Old Beach locality.

Description

Both U.T.G.D. 87871 (fig. 3), a nearly complete left palatal tooth plate and U.T.G.D. 95100 (fig. 3), a nearly complete left mandibular tooth plate, exhibit nearly triangular outlines in occlusal view. Five straight, minutely denticulated radially arranged ridges present on palatal plate, four on mandibular plate. Medial and anterior borders of both straight. Angle formed by anterior and medial borders slightly in excess of 90° on palatal plate, approximately 90° for mandibular plate. Labial borders of both convex with distal portions of ridges set off from each other by concave excavations that become increasingly shallower proceeding from anterior ridges towards posterior ridges. Length of palatal dental plate, as measured from anteromedial angle to posterior tip of medial border, 14 mm; that of mandibular dental plate, which lacks posterior tip of medial border, approximately 7 mm. Greatest width of palatal plate, on line extending perpendicular to medial border to distal tip, second ridge, 9 mm; length first ridge of mandibular plate, whose distal portion has been broken off, approximately 8 mm. Ridges of both plates sharply angular in cross section. All ridges on each plate project labially and posteriorly from anteromedial corner. Three anteriormost ridges of palatal plate joined together at the anteromedial corner independently of each other, whereas ridges four and five fuse together at point posterior to the anteromedial corner. Ridges one, two, and four of mandibular plate joined together at the anteromedial corner independently of each other, whereas ridge three fuses with the fourth at point posterior to anteromedial corner. In labial view both palatal and mandibular plate exhibit "V" shaped valleys between ridges with valley between ridges one and two wider and deeper than those between more posterior ridges. Ridge crests of both plates exhibit anteriorly orientated angulation.

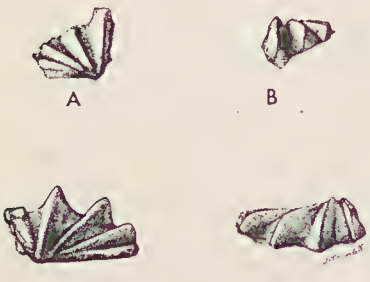


Fig. 3. - *Ceratodus gypsatus* Quenstedt, 1885, U.T.G.D. 95100 (Coningham locality); left mandibular dental plate: A. occlusal view; B, labial view. U.T.G.D. 87871 (Midway Point locality); left palatal dental plate: C, occlusal view; D, labial view ; x 1.6.

Comparisons

The Knocklofty *Ceratodus* has been compared with the majority of other Triassic representatives of this genus which have been described and illustrated in the literature. On the basis of palatal plate ridge count, the fashion in which these ridges

join the medial border of the dental plate and the angle formed by the first ridge and the medial border, the Knocklofty *Ceratodus* is indistinguishable from *C. gypsatus* Quenstedt, 1885 from the Keuper deposits of Wurtemberg, Germany and is, therefore, assigned to this species. *C. ornatus* Broom 1909 from the Upper Triassic Stormberg series at Burghersdorp, South Africa and *C. palaeorincinatus* Frentzen 1924, from the Lower Triassic Bunter deposits of Baden, Germany are also indistinguishable from the type of *C. gypsatus* and are placed in synonymy with this species.

Remarks

Miall (1878, p.12), in his revision of a number of *Ceratodus* species originally described by Oldman (1859) from the Upper Triassic Maleri Formation of India, concluded that the palatal plates of *Ceratodus* could be distinguished from those borne on the mandible as the former posses an additional ridge, i.e., five on the palatal plate if four are present on the mandibular plate. Supportive evidence favouring Miall's supposition which the present author is in agreement with through consideration of the Tasmanian material, is provided by Zittel (1886), who noted that the palatal plates of *Neoceratodus forsteri* differ from those borne on the mandible through the possession of an additional ridge, i.e., seven versus the six present on the mandibular plate.

Order CROSSOPTERYGII
Suborder COELACANTHINI
Family COELACANTHIDAE Agassiz, 1843

Diagnosis : See Schaeffer (1948, pp. 28-29).

Coelacanthidae gen. et sp. indet.
(Fig.4, Pl. 1)

Material

U.T.G.D. 87821, fragment of vertical posterior limb of left pterygoid. U.T.G.D. 95099 and 85756, two undeterminable palatal bone fragments. All from a clay-pebble conglomerate matrix.

Locality : Midway Point.

Description

Pterygoid fragment (fig. 4) closely resembles that of *Wimania sinuosa* (Stensio 1921, fig. 26). Lateral surface concave, medial surface convex. Medial surface minutely denticulate. Lateral surface bears two distinct ridges that diverge dorsally from ossification centre of element. Anterior ridge increases in both breadth and thickness dorsally. In cross-section, anterior surface of this ridge concave, posterior surface convex. Only ventral portion of posterior ridge present, this structure not confluent with proximal portion of anterior ridge.

U.T.G.D. 95099 (pl. 1) and U.T.G.D. 85756 each exhibits one minutely denticulated surface similar to that exhibited on medial surface of pterygoid fragment.

Comparisons

As noted by Schaeffer and Gregory (1961) "the shape and proportions of the pterygoid may differ sufficiently from genus to genus to make this element of some diagnostic significance. It is doubtful, however, that these differences are distinctive enough to warrant the erection of a new genus on the basis of an isolated example." Due to its fragmentary nature, assignment of the Tasmanian pterygoid to any of the previously erected coelacanthid genera where this structure is known (Schaeffer and Gregory, 1961, fig. 6) is not possible.

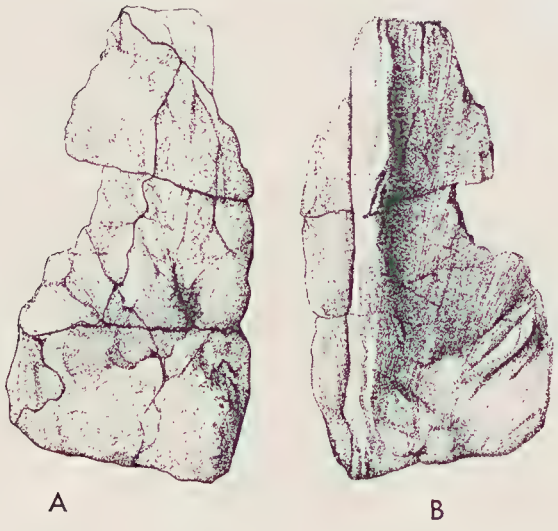


FIG. 4.- Coelacanthidae gen. et sp. indet., U.T.G.D. 87821 (Midway Point locality); fragment of vertical posterior limb of left pterygoid: A, medial view; B, lateral view. anterior to left, dorsal to top; x 1.4.

Subclass ACTINOPTERYGI
Infraclass CHONDROSTEI
Order PALAEONISCIFORMES
Suborder PALEONISCOIDEI
Family ACROLEPIDAE Aldinger, 1937

Diagnosis: See Obruchev (1964, pp. 545-546).

Genus ACROLEPIS Agassiz, 1833

Diagnosis: See Aldinger (1937, p. 257).
Type species: *Acrolepis sedgwicki* Agassiz, 1833

Acrolepis hamiltoni Johnston and Morton, 1890

1890 *Acrolepis? hamiltoni* Johnston and Morton: 102-103, 2 Plates
1891 *Acrolepis hamiltoni* Johnston and Morton: Johnston and Morton: 152-154
1930 *Acrolepis hamiltoni* Johnston and Morton: Wade; 125
1937 *Acrolepis hamiltoni* Johnston and Morton; Aldinger; 259
1974 *Acrolepis hamiltoni* Johnston and Morton; Cosgriff; 5

Holotype

T.M. Z 1377, the left lateral impression of a poorly preserved, laterally compressed fish, on a sandstone matrix lacking or poorly exhibiting the following structures; the anterior portion of the head; the pelvic fins; and part of the anal fins.

Type Locality

Cascades locality.

Remarks

At present little can be added to our knowledge of this form. As shown by the plates included with Johnston and Morton's description, the holotype was originally comprised of both a left and a right lateral imperssion. Currently only the left lateral impression is available for study. Due to its poor state of preservation the present author is of the opinion that Johnston and Morton must have based the better portion of their description on the now missing right lateral impression. Therefore, morphological data employed in comparing this form to *A. tasmanicus* is at present, totally dependent upon Johnston and Morton's description.

Acrolepis tasmanicus Johnston and Morton, 1891
(Plates 2, 3)

1891 *Acrolepis tasmanicus* Johnston and Morton 152-154.
1930 *Acrolepis tasmanicus* Johnston and Morton: Wade; 125.
1937 *Acrolepis tasmanicus* Johnston and Morton: Aldinger; 261.
1974 *Acrolepis tasmanicus* Johnston and Morton: Cosgriff; 5.

PLATE 1.- Coelacanthidae gen. et sp. indet., U.T.G.D. 95099 (Midway Point locality); indeterminable palatal bone fragment: A, medial view; B, lateral view; x1.33.

Holotype

T.M. Z 1374 and T.M. Z 1375, the left and right lateral impressions of a nearly complete vertically compressed fish, on a sandstone matrix lacking only the distal portion of the upper lobe of the caudal fin, skull badly crushed.

Paratype

A single specimen T M Z 1996 in the collection of the Tasmanian Museum and Art Gallery (plates 2,3) consisting of the right lateral impression of a fairly complete, laterally compressed fish, on a sandstone matrix, exhbiting a partially crushed skull. Unfortunately, while the exact locale from which this specimen was procured is not known with assurance, the author is of the opinion that the paratype was collected from strata assignable to the Knocklofty Formation. Lithologic similarity and mode of preservation support this conclusion.

Diagnosis

A comparatively small acrolepid which most closely resembles *A. hamiltoni* but differs from this form is that it possesses a greater number of transverse scale rows 66 as compared to 55 noted for *A. hamiltoni*.

Description

An elongate fusiform fish exhibiting the following morphometric parameters.

	Holotype	Paratype
Total length:	140 mm	154 mm
Standard length	116 mm	115 mm
Head length	26 mm	30 mm

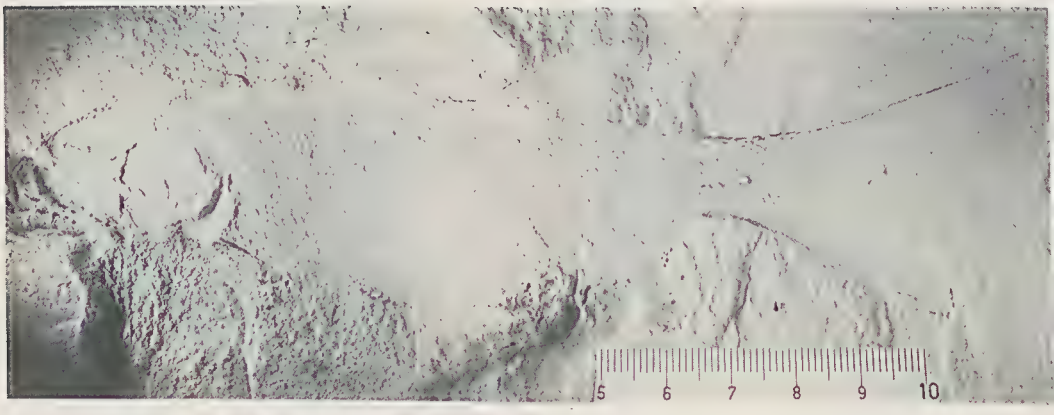


PLATE 2.- *Acrolepis tasmanicus* Johnston and Morton, 1890; paratype, TM Z 1996 (exact locale unknown), overall view;x0.8.

	Holotype	Paratype
Snout length:	3 mm	4 mm
Snout to origin of pelvic fin:	52 mm	47 mm
Snout to origin of dorsal fin:	70 mm	68 mm
Snout to origin of anal fin	83 mm	79 mm
Length of caudal peduncle	15 mm	17 mm
Maximum depth of trunk	29 mm	31 mm
Minimal depth of caudal peduncle	9 mm	12 mm

Skull

Snout blunt. Orbits large and anteriorly placed. Suspensorium oblique. Mout subterminal. Dentition moderately strong. Dermal bone ornamentation consists of radiating ridges of tubercles.

Paired Fins

Pectoral fins originating on ventral posterior aspect of cleithrum, exhibiting a fan-shaped outline. Approximately 17 distally articulated and bifurcated lepidotrichia present. Pelvic fins poorly preserved. Lepidotrichia fully articulated and distally bifurcated. Anterior margin originates between posterior border of skul and anterior base of dorsal fin, closer to the former.

Unpaired Fins

Dorsal fin triangular. Anterior border slightly convex and equipped with fringing fulcral scales. Anterior border arises in advance of anterior origin of anal fin. Posterior border concave. Approximately 36 fully articulated and distall

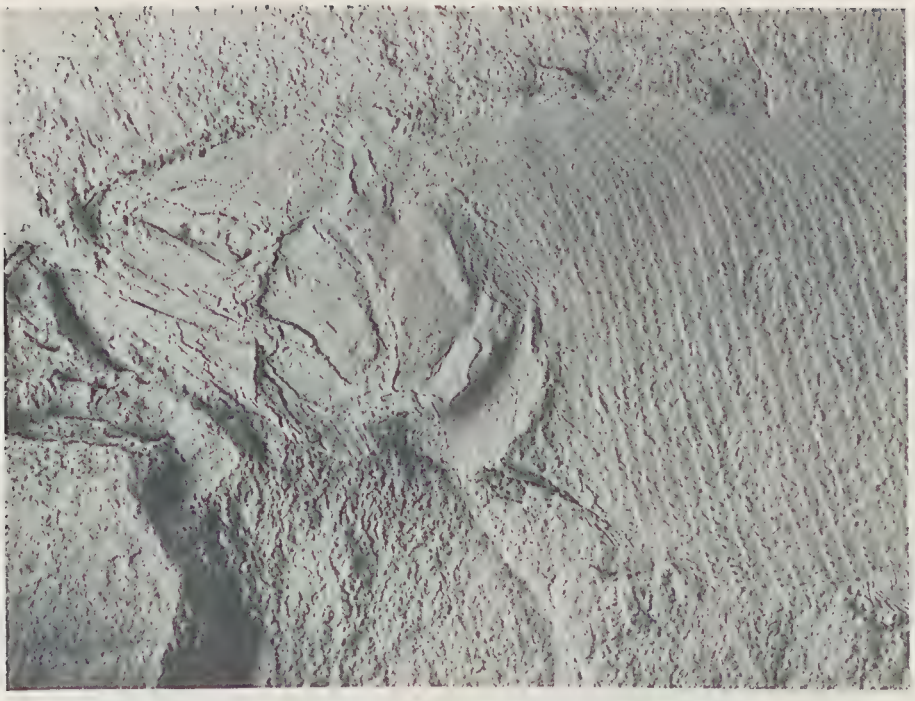


PLATE 3.- *Acrolepis tasmanicus* Johnston and Morton, 1890; paratype, (TM) Z 1996 (exact locale unknown); skull in lateral view; x2.

bifurcated lepidotrichia present. Caudal fin heterocercal, deeply cleft and unequally lobate with dorsal lobe longer. Both upper border of dorsal lobe and lower border of ventral lobe fringed by delicate fulcral scales. Lepidotrichia fully articulated and distally bifurcated. Total number of lepidotrichia believed not to be in excess of 85. Anal fin similar to dorsal in size and outline. Lepidotrichia fully articulated and distally bifurcated. Approximately 38 lepidotrichia present.

Squamation

Scales rhombic, borders smooth. Scale depth greatest in central region of trunk. Scale depth relative to length decreases gradually as dorsal and ventral borders of trunk are approached. Same trend observed when proceeding from posterior portion of trunk towards tail. Transverse body scale rows oriented posteroventrally across the body with angle of orientation to long axis of body becoming more oblique as posterior part of trunk is approached. Scale ornament consisting of a variable number of obliquely-oriented, gently undulating striae emanating from the posteroventral corner of scales. Some striae observed to branch in an irregular fashion as they are traced towards dorsal and anterior scale borders. Angle of striae orientation becomes more horizontal as ventral and dorsal obrders of trunk are approached.

Comparisons

A comparatively small acrolepid which most closely resembles *A. hamiltoni* but differs from this form in that it posseses a greater number of transverse scale rows 66 as compared to 55 noted for *A. hamiltoni*.

Both Tasmanian species can be distinguished from *A. sedgwicki*, the type species

of the genus, by the following combination of morphological features. First, *A. sedgwicki* is considerably larger (a feature of perhaps dubious taxonomic value) than either of the Tasmanian forms. Secondly, *A sedgwicki* as figured by Agassiz (1833) possesses a series of very robust fulcral scales along the dorsal border of the caudal fin, a condition not present in either of the Tasmanian forms. Thirdly, the pelvic fins of *A sedgwicki* are positioned much more dorsally than in either of the Tasmanian forms.

Both *A. hamiltoni* and *A. tasmanicus* are distinguishable from *A. ortholepis*, as described by Woodward (1891, p. 508), *A. rhombifer*, as shown by Obruchev (1964, p. 546, fig. 38), and *A. macropoma* as described by Berg (1940, p. 448), on the basis of scale ornamentation.

Comparisons between the Tasmanian forms and *A. macroderma* are not possible at this time.

Acrolepis ? sp.
(Plate 4)

Material

U.T.G.D. 95098, a much distorted fish, folded upon itself, and lacking skull, pelvic fins and anal fin. The anterior and middle portion of the trunk are dorsoventrally compressed but the posterior portion of the trunk and tail are laterally compressed. The fish is embedded in a gray clay clast contained in a clay-pebble conglomerate matrix. The specimen is split through and thus contained in two matching parts: U.T.G.D. 95098a which includes part of the squamation, the right pectoral fin and the dorsal and caudal fins; and U.T.G.D. 95098b which exhibits other portions of the squamation and a portion of caudal fin.

Locality

Old Beach locality.

Description

Body fusiform. Preserved fragment of right pectoral fin comprised of approximately seven unarticulated lepidotrichia. Portion of dorsal fin present too poorly preserved to provide details of shape and construction. Caudal fin heterocercal, deeply cleft and with fully articulated lepidotrichia.

Squamation best preserved on caudal peduncle and dorsal part of trunk. Scales rhombic with smooth borders. Depth of scale does not exceed scale length. Nature of ornamentation, if originally present, not determinable due to incomplete state of preservation.

Comparisons

On the basis of morphological features exhibited by this particular specimen including the unarticulated lepidotrichia of the pectoral fin, the structure of the caudal fin and the shape and proportions of the visible scales it is clearly referrable to the genus *Acrolepis*. It does not, however, preserve any of the difinitive characters that would allow it to be assigned with certainty to either of the Tasmanian species or to any of those from other areas.

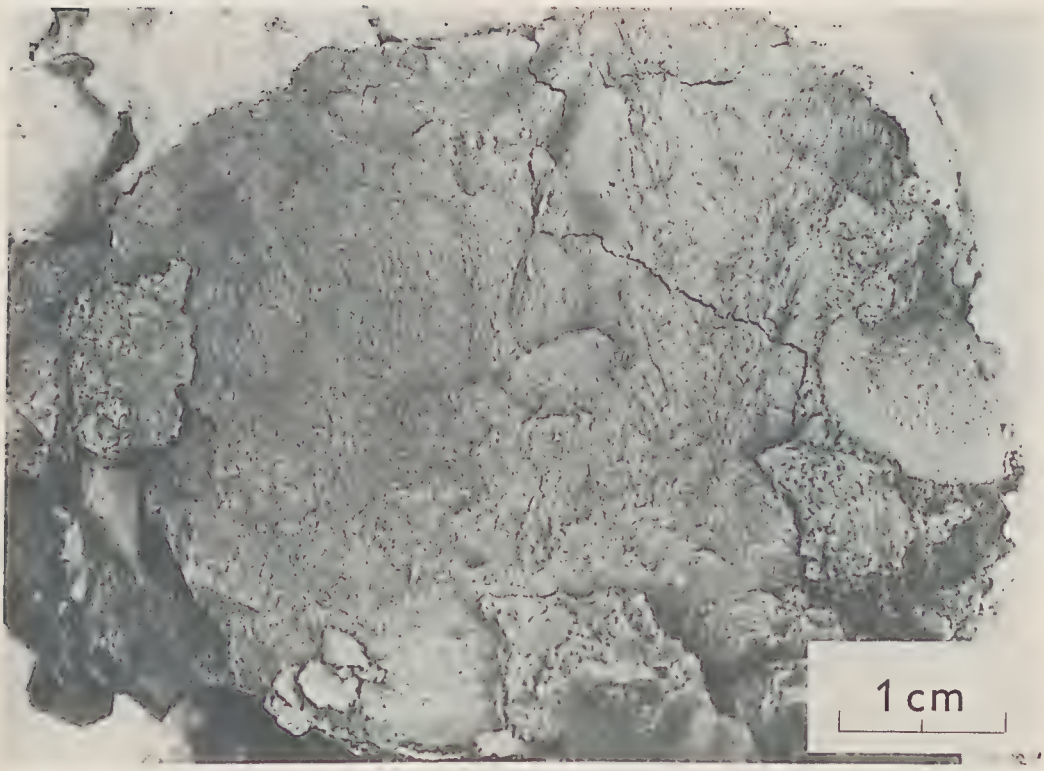


PLATE 4.- *Acrolepis ? sp.* U.T.G.D. 95098a (Old Beach locality); overall view ; x 2.

Suborder PERLEIDOIDEI
Family CLEITHROLEPIDAE Wade, 1935

Diagnosis: See Hutchinson (1973, p. 302).

Genus *CLEITHROLEPIS* Egerton, 1864

Diagnosis: Emended diagnosis as given by Hutchinson (1973, p. 311)
Type Species: *Cleithrolepis granulata* Egerton 1864.

Cleithrolepis granulata Egerton, 1864
(Plates 5, 6)

1974 *Cleithrolepis*: Cosgriff, 3.

Referred Material
U.T.G.D. 87801, fish with an incomplete and badly crushed skull, missing all fins. Unique specimen in two parts, U.T.G.D. 87801a consisting of skull and anterior portion of trunk and U.T.G.D. 87801b containing the posterior portion of the trunk. Specimen imbedded in gray clay-pebble contained in a clay-pebble conglomerate matrix.

PLATE 5.- *Cleithrolepis granulata* Egerton, 1864; U.T.G.D. 87801a (Coningham locality); skull and anterior portion of trunk in lateral view; x 2.

Locality

Stream deposited conglomerates at the Coningham locality (see Cosgriff 1974, p. 119).

Description

A laterally compressed, deep bodied fish. Opercular "D"-shaped, deeper than wide. Subopercular badly crushed and incomplete.

Scales in region of lateral line much deeper than wide. Relative depth of scales in proportion to length decreases as dorsal and ventral borders of trunk are approached. Unfortunately, because of the nature of preservation, nothing can be said of the scale ornament.

Comparisons

Evidence favoring the assignment of the Tasmanian form to *Cleithrolepis* instead of the closely related South African genus *Cleithrolepidina* (Berg, 1940 Hutchinson, 1973) is provided by the relative proportions of the opercular. This structure being deeper than wide in both *Cleithrolepis granulata* and the Tasmanian form, the reverse of this condition being true of the forms assigned to *Cleithrolepidina*.

The provisional assignment of the Tasmanian form to *C. granulata* is based on the close agreement in body outline of the two forms when compared to that exhibited by *C. alta* in which the trunk is much deeper. The ratio of standard-length minus head length to body-depth in both *C. granulata* as figured by Hutchinson (1973, fig. 43) and the Tasmanian specimen assigned to this species is approximately 1.00 whereas in the case of *C. alta* as figured by Wade (1935, fig. 28) it is approximately 0.83.

Order ACIPENSERIFORMES

Family SAURICHTHYIDAE (Woodward, 1888)

Diagnosis: See Gardiner (1960, p. 271).

Genus *SAURICHTHYS* Agassiz, 1834

Diagnosis: See Stensio (1925, pp. 12-13).

Type Species: *Saurichthys apicalis* Agassiz, 1834.

Saurichthys sp.

(Plates 7,8)

1974 *Saurichthys:* Cosgriff, 3.

Referred Material

U.T.G.D. 87866, posterior portion of right side of head, comprised of dermal elements of both upper and lower jaws and anterior portion of opercular apparatus The specimen is approximately 35 mm in length and in two separate parts embedded in a clay-pebble conglomerate matrix. U.T.G.D. 87866a (Pl. 7) is comprised of the actual

dermal elements and U.T.G.D. 87866b (Pl. 8) is an impression of the former and exhibits the sculpture pattern of the dermal bones present.

Locality: Coningham.

Description

Of the dermal elements present, only the anterior portion of the opercular is clearly visible. This bone possesses a shallow "V"-shaped anterior border whose apex is directed posteriorly. The ornament consists of closely-spaced, fine striae forming a pattern of concentric hemicircles whose center of radiation is located on the center of the anterior border of the bone.

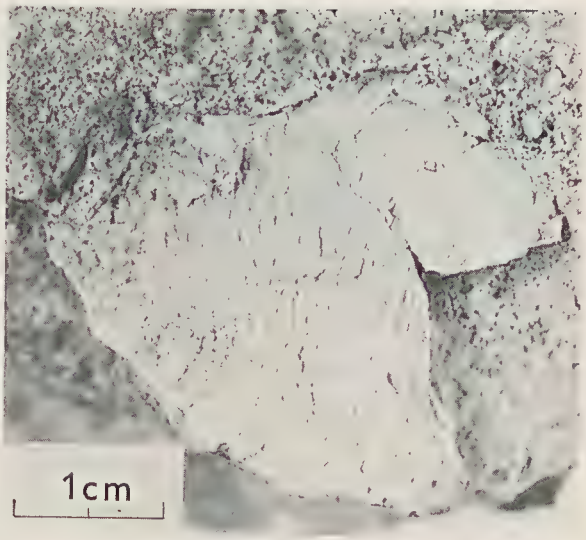


PLATE 6.- *Cleithrolepis granulata* Egerton, 1864; U.T.G.D. 87801b (Coningham locality); posterior portion of trunk in lateral view; x 2.

The posterior portion of the right lower jaw is elongate and shallow, gradually deepening posteriorly. No teeth are visible. Due to the nature of preservation, the individual dermal bones that usually comprise this structure in other members of the genus (angular, supraangular and posterior portion of the dentalosplenial) cannot be differentiated. The ornamentation consists of numerous closely spaced striae resembling those of the opercular. Those on the ventral surface are parallel to the longitudinal axis and those on the lateral surface are orientated obliquely.

On the upper jaw, the dermal elements believed present on the Tasmanian specimen, through comparison with *S. ornatus* Stensio (1925, p. 10, fig. 3) include remnants of the quadratojugal and preopercular. Suture lines between these two elements cannot be discerned and thus their shapes are not determinable.

Comparisons

Evidence for the inclusion of the above described Tasmanian material in the genus *Saurichthys* includes the elongate nature of the skull as well as the nature of the ornamentation exhibited on the skull and mandible. With regard to these features the Tasmanian form cannot be distinguished from such described species as *S. ornatus* Stensio, 1925 from the Lower Triassic of Spitsbergen, *S. gigas* and *S. gracilis* (Woodward, 1890) both from the Lower Triassic Gosford Formation at Gosford, New South Wales, *S. parvidens* Wade, 1935 from the Middle Triassic Hawkesbury Sandstone at Brookvale, New South Wales, and *S. striolatus* (Bronn, 1858) from the Upper Triassic of Raibl, Austria. Therefore, the assignment of this form to any previously described species or the consideration that it may represent a new species must await the discovery of more complete material.

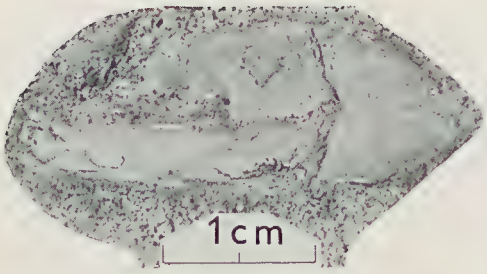


PLATE 7.- *Saurichthys sp.*, U.T.G.D. 87866a (Coningham locality); portion of skull and lower jaw in lateral view ; x 2.

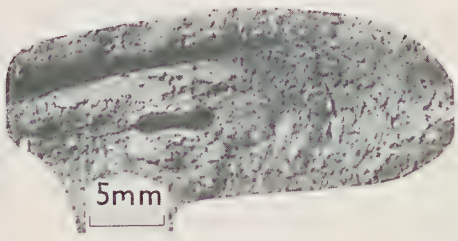


PLATE 8.- *Saurichthys sp.*, U.T.G.D. 87866b (Coningham locality); impression of portion of skull and lower jaw exhibiting surface sculpture in lateral view.

CONCLUSIONS

Osteichthyan remains representing five genera are associated in the fresh-water deposited sediments of the Early Triassic Knocklofty Formation of Tasmania with the four species of temnospondylous amphibians described by Cosgriff (1974) and the semi-aquatic crocodile-like proterosuchian reptile *Tasmaniasaurus triassicus* (Camp and Banks, 1978). The total osteichthyan assemblage presently known from the unit includes the dipnoan, *Ceratodus gypsatus* Quenstedt, 1885, a coelacanth, a palaeoniscoid *Acrolepis hamiltoni* Johnston and Morton, 1890, a perleidoid, *Cleithrolepis granulata* Egerton, 1864 and a saurichthyid, *Saurichthys* sp.

Unfortunately, the osteichthyans known from this composite assemblage are of little biostratigraphic value as each of the genera present had a considerable time range. Remains assignable to the dipnoan genus *Ceratodus* have been identified from deposits ranging in age from Lower Triassic to Upper Cretaceous (Schaeffer 1970, p. 377). Forms included in the chondrostean genus *Acrolepis* have been described from deposits varying in age from Mississipian to Lower Triassic (Aldinger 1937, p. 259-261). Finally, representatives of the genera *Cleithrolepis* (Hutchinson 1973, p. 312) and *Saurichthys* (Romer 1966, p. 353) are known from deposits ranging in age from Lower to Upper Triassic.

It is now known (from unpublished data) that this fresh-water osteichthyan assemblage differs from other such assemblages of comparable age in that endemic genera are completely lacking.

Ceratodus ornatus Broom, 1909 and *C. palaeorunginatus* Frentzen, 1924 have been placed in synonymy with *C. gypsatus* Quenstedt, 1885.

ACKNOWLEDGEMENTS

The author renders his most sincere gratitude to the following people without whose aid and constant encouragement this research would not have been possible: Dr. J.W. Cosgriff, Professor, Department of Biology, Wayne State University, for reviewing the entire text of this manuscript and for his many valuable suggestions with regard not only to the format but also certain portions of the content as well; Miss J. Kaupus

for typing the text of this paper; Dr W. Hammer, Department of Biology, Wayne State University and Noel Kemp, Tasmanian Museum, Hobart, for preparing most of the photographs that appear in this paper; Miss J. Lindell for preparing the illustrations that accompany this text; the board of directors of the National Geographic Society for providing the generous financial support that enabled the author and Dr. J.W. Cosgriff to travel to Tasmania during early 1971 in order to collect additional materials; Dr. M.R. Banks, University of Tasmania, for placing on loan to the author previously acquired materials as well as providing facilities and general assistance to the field program; Mr. L. Sutherland, formerly Curator of Geology, Tasmanian Museum, Hobart, and Mrs. Smith, proprietor of the Port Arthur Museum for allowing the author to take latex peels of fossil fish material housed at these institutions.

REFERENCES

Agassiz, L., 1833-44: *Recherches sur les poissons fossiles* 5 vols. pp.1420 + 369 plates. Neuchatel.

Aldinger, H., 1937: Permische Ganoidfische aus Ostgronland. *Meddr. Gronland*, 102 (3): 1-392.

Berg, L.S., 1940: Classification of fishes, both recent and fossil. *Trudy zool. Inst.* Lehnigr., 5: 85-517.

Broom, R., 1909: The fossil fishes of the Upper Karroo beds of South Africa. *Ann. S. Afr. Mus.*, 7: 251-269.

Camp, C.L. and Banks, M.R., 1978: A proterosuchian reptile from the Early Triassic of Tasmania. *Alcheringa*, 2(2): 143-158.

Cosgriff, J.W., 1974: Lower Triassic Temnospondyli of Tasmania. *Spec. Pap. geol. Soc. Amer.*, 149: 1-134.

Egerton, P., 1864: On some ichthyolites from New South Wales forwarded by the Rev. W. B. Clark. *Q. J. geol. Soc. Lond.*, 20: 1-5.

Frentzen, K., 1924: *Ceratodus palaeoruncinatus n. sp.* aus dem oberen Buntsandstein der Gegend von Durlach in Baden. *Zentbl. Miner. Geol. Palaont.*, 216-220.

Gardiner, B.G. 1960: A revision of certain actinopterygian and coelacanth fishes, chiefly from the Lower Lias. *Bull. Br. Mus. nat. Hist., Geology*, 4(7), 239-384.

Hutchinson, P., 1973: A revision of the redfieldiiform and perleidiform fishes from the Triassic of Bekker's Kraal (South Africa) and Brookvale (New South Wales). *Bull. Br. Mus. nat. Hist., Geology*, 22(3): 233-354.

Johnston, R.M. and Morton, A., 1890: Notes on the discovery of a ganoid fish in the Knocklofty sandstones, Hobart: *Pap. Proc. R. Soc. Tasm.*, 1887: 102-104.

_____., 1891, Description of a second ganoid fish from the Lower Mesozoic sandstone near Tinderbox Bay: *Pap. Proc. R. Soc. Tasm.*, 1890: 152-154.

Miall, L.C., 1878: Monograph of the sirenoid and crossopterygian ganoids: *Palaeontogr. Soc. (Monogr.)*, 32: 1-32.

Obruchev, D.V. (ed.), 1964, Vol. XI, Agnatha, Pisces. In Orlov, Y.A. (ed), FUNDAMENTALS OF PALEONTOLOGY. Jerusalem, Israel Program of Scientific Translation, x + 825 pp.

Oldham, T., 1859: On some fossil fish-teeth of the genus *Ceratodus*, from Maledi, south of Nagpur. *Mem. geol. Surv. India*, 1.

Quenstedt, F.A., 1885: HANDB. PETREFAKT, 3rd edit. (1883): 297.

Romer, A.S., 1966: VERTEBRATE PALEONTOLOGY: 3rd ed. revised. University of Chicago Press, Chicago, 468 p.

Schaeffer, B., 1948: a study of *Diplurus longicaudatus* with notes on the body form and locomotion of the Coelacanthini. *Am. Mus. Novit.*, 1378: 1-32.

_____, 1970: Mesozoic fishes and climate. *N. Amer. Paleontol. Conv., Proc. Part D.*: 376-388.

_____, and Gregory, J.T., 1961: Coelacanth fishes from the continental Triassic of the western United States. *Am. Mus. Novit.*, 2036: 1-18.

Schmidt, M., 1928: DIE LEBEWELT UNSERER TRIAS. Oehringen, Ferdinand Rau: 1-461.

Stensio, E.A., 1921: TRIASSIC FISHES FROM SPITZBERGEN. Part 1, Vienna. pp.307 + 35 pls.

_____, 1925: Triassic fishes from Spitzbergen. Part II. *Svenska Vet.-Akad. Handl*, (5) 11(1): 261 pp.

Wade, R.T., 1930: The fossil fishes of the Australian Mesozoic rocks: *J. Proc. R. Soc. N.S.W.*, 64: 115-147.

_____, 1935: The Triassic fishes of Brookvale, New South Wales. *British Museum (Natural History)*.

Woodward, A.S., 1888: On two new lepidotid ganoids from the early Mesozoic deposits of Orange Free State, South Africa: *Q. J. geol. Soc. Lond.*, 44.

_____, 1890: The fossil fishes of the Hawkesbury series at Gosford, New South Wales. *Mem. geol. Surv. N.S.W.*, 4: 1-55.

_____, 1891: CATALOGUE OF THE FOSSIL FISHES IN THE BRITISH MUSEUM. Part II. London, xliv + 567 pp.

Zittel, K.A., 1886: Ueber *Ceratodus*. *Sber. Akad. Wiss. Wien*, 1889: 253-261.

Papers and Proceedings of the Royal Society of Tasmania, Volume 114, 1980

(ms. received 21.2.1980)

PETTERDITE RE-ANALYSED

by Ramsay J. Ford and Noel R. Kemp
University of Tasmania and Tasmanian Museum and Art Gallery

(with one plate)

ABSTRACT

FORD, R.J., and KEMP, N.R., 1980 (31 v): Petterdite re-analysed. *Pap. Proc. R. Soc. Tasm.*, 114: 161-163 (incl. one plate). ISSN 0080-4703. Department of Geology, University of Tasmania, Hobart and Tasmanian Museum and Art Gallery, Hobart, Tasmania, Australia.

Petterdite is mimetite with about 5%-17% pyromorphite in solid solution.

INTRODUCTION AND PREVIOUS WORK

At the beginning of this century, the Government Geologist, W.H. Twelvetrees described and figured a new mineral species, petterdite, named in honour of his friend, W.F. Petterd (Twelvetrees 1902). Classical properties were described and an analysis by E.O. White of Hobart was included. The locality for the specimen analysed was given as the superficial workings of the Brittania mine, Zeehan. The analysis submitted by White was as follows:

PbO	= 74.04
As_2O_5	= 2.60
P_2O_7	= 2.10
Sb_2O_5	= 0.50
Cl	= 10.00
TOTAL	99.24

The mineral was proclaimed on the basis of the analysis which did not conform to any known mineral.

Anderson (1906), using crystallographic measurements, suggested that this mineral was probably a form of mimetite, but, no further analytical work was included in the study. Subsequently Petterd in his compilation of The Minerals of Tasmania (Petterd 1910, 118) included petterdite as a variety of mimetite.

Petterd bequeathed his collection of some 2500 specimens to the Royal Society of Tasmania who loaned it to the Trustees of the (then) Tasmanian Museum and Botanical Gardens for a period of 999 years. In the accompanying hand-written catalogue the Trustees received, are included details of four specimens of petterdite:
No. 633 from Zeehan, No. 634 from Mt Read, No. 635 from Mt Read, No. 636 from Zeehan. Only Nos. 633 and 634 are now extant.

X-ray diffraction studies made on specimen No. 633 showed it to be adamite (Department of Mines 1970,9). Presumably on the basis of this result, specimen No. 634 was relabelled "adamite" also. However, No. 634 has now been analysed by x-ray diffraction and is similar to specimen 622.

The "type specimen" of petterdite, recognizable from the excellent photograph (Twelvetrees 1902) was found in the collection of the Museum and Art Gallery labelled as matlockite from Cromford, Derbyshire, England with the number 622. The hand-written 1910 catalogue lists specimen no. 622 as matlockite from that same locality. The source of this confusion can now only be conjecture as the mistake was made more than 70 years ago. Some small crystals from this specimen were removed for chemical

and x-ray diffraction analysis.

CHEMICAL ANALYSIS

The sample was analysed using atomic absorption flame photometry for lead and arsenic, solution spectrophotometry for phosphorous and fluorine, and ion selective electrodes for chlorine and fluorine. A.R. Pb $(NO_3)_2$, As_2O_3, NaCl, NaF and U.S. International Standard phosphate (NbS 120b) were used as standards. Standard solutions were prepared with similar element concentrations to that of the sample.

Results:

PbO	= 76.26
As_2O_5	= 21.23
P_2O_5	= 2.02
Cl	= 2.00
F	= 0.08
V_2O_5	= 0.00
TOTAL	101.59

P. Robinson - analyst.

Atomic proportions

Pb	= 0.34055
As	= 0.18553
P	= 0.02841
Cl	= 0.05641
F	= 0.00421

Atomic proportions on the basis of Pb_5

Pb	= 5.00
As	= 2.72
P	= 0.42
Cl	= 0.83
F	= 0.06

Pyromorphite-mimetite = $Pb_5\ [P,As)O_4]_3Cl$

"Petterdite" this analysis = $Pb_5[(As,P)O_4]3.14^{Cl},F_{0.89}$

X-RAY DIFFRACTION ANALYSIS

Applying the method of Baker (1966) to specimen 622, "d" spacings for the lines 11.2 and 30.0 were measured with a Philips diffractometer using fluorite as the internal standard and Cu*Kα* radiation. These results were then applied to the determinative diagram (op.cit.). "Petterdite" gave d11.1 = 3.001 A.U. and d 30.0 = 2.947 A.U. From the determinative diagram these lead to a proportion between 83%-88% of the mimetite molecule in solid solution with pyromorphite, in good agreement with the analytical results. Specimen No. 634 has d11.2 = 3.011 A.U. and d30.0 = 2.951 A.U. giving a mimetite proportion ranging from 87% to 95%.

CONCLUSION

Clearly the mineral is part of the pyromorphite-mimetite series. [Pyromorphite - $Pb_5(PO_4)_3Cl$, Mimetite - $Pb_5(AsO_4)_3Cl$]. In the analysis the halogen element is deficient while the oxygen anion complex has an excess. These may be related to impurities in the mineral and to the difficulties associated with analysing small samples. There could also be (OH) replacing halogens. On the basis of the analysis the proportion of the mimetite molecule is 86.62%.

REFERENCES

Anderson, C., 1906: Mineralogical notes: No. 111 - axinite, petterdite, crocoite and datolite. *Rec. Aust. Mus.* 6(3) : 133-144.

Baker, W.E., 1966: *American Mineralogist*, 51: 1712-144.

Department of Mines, 1970: CATALOGUE OF THE MINERALS OF TASMANIA. *Geol. Surv. Rec.* 9: 1-110, 12 pls.

Petterd, W.F., 1910: *Pap. Proc. R. Soc. Tasm.* 1-221.

Twelvetrees, W.H., 1902: Description and analysis of a new species of mineral, petterdite, a new oxychloride of lead. *Pap. Proc. R. Soc. Tasm.*, 1900-1901 (1902): 51-52, 1 pl.

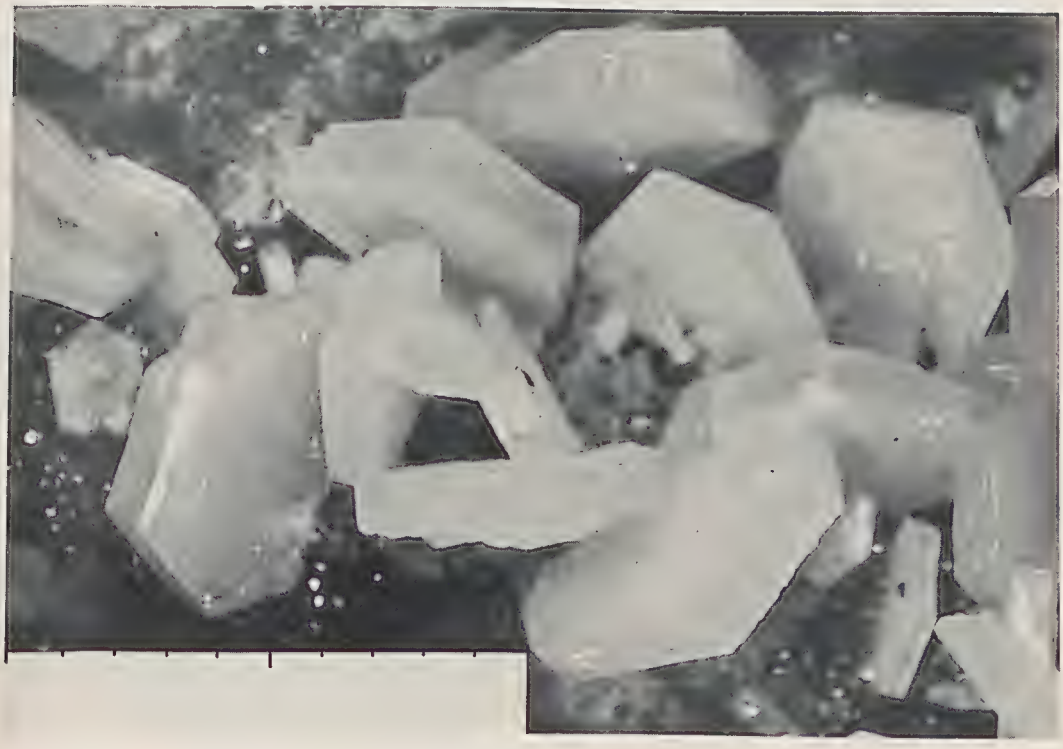


PLATE 1.- Twinned crystals of mimetite, part of specimen 622, holotype of "petterdite." Scale bar 10 mm.

Papers and Proceedings of the Royal Society of Tasmania, Volume 114, 1980

(ms. received 20.8.1979)

AN EARLY MIOCENE FLATHEAD (PISCES: PLATYCEPHALIDAE) FROM WYNYARD, TASMANIA

by Keith D. Corbett
Geological Survey of Tasmania, Hobart

(with three text figures and one plate)

ABSTRACT

CORBETT, K.D., 1980 (31 v): An Early Miocene flathead (Pisces, Platycephalidae) from Wynyard, Tasmania. *Pap. Proc. R. Soc. Tasm.*, 114: 165-175 (incl. one plate). ISSN 0080-4703. Geological Survey of Tasmania, Department of Mines, Hobart, Tasmania, Australia.

A well-preserved flathead skull from the Early Miocene marine beds near Wynyard is described. A comparison with the modern sand flathead *Platycephalus bassensis* Cuvier reveals a very close similarity.

INTRODUCTION

A fossil fish skull was collected by the author from the Early Miocene Fossil Bluff Sandstone (Banks 1962, p. 235; Quilty 1972, p. 30) about 400 m west of Fossil Bluff, Wynyard, in 1962. The skull was in a large boulder of friable glauconitic sandstone at the base of the low shoreline cliff, and was well preserved, with most of the bones still present. The broad, flat nature of the skull and the low bony ridges on the dorsal surface suggested it might be a flathead, and an examination of the skull of the modern sand flathead, *Platycephalus bassensis* Cuvier 1829, revealed a striking similarity. Undoubtedly the fossil skull belongs to the same genus, but the lack or poor preservation of several of the critical bones in the fossil, and the lack of detailed osteological descriptions of most of the modern species, precludes placing the fossil with certainty in one of the present-day species.

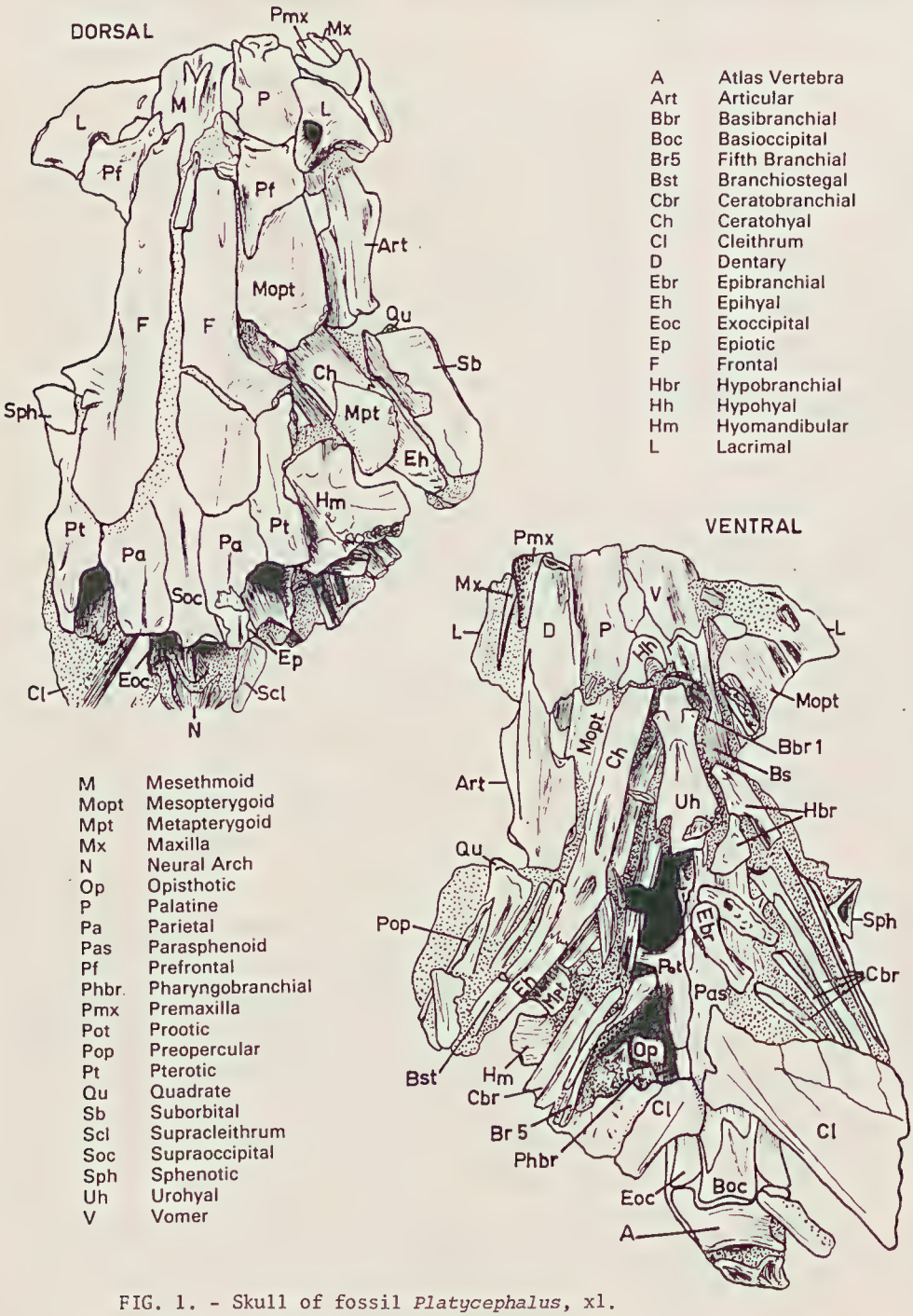
This appears to be the first record of a fossil flathead. The specimen is in the collection of the Geology Department, University of Tasmania (No. 57519).

DESCRIPTION OF THE FOSSIL SKULL
(see Figs. 1 and 3 and Plate I)

Nomenclature used in the following sections is that of Gregory (1951). Although the characteristic vomerine teeth and preopercular spines are missing, the skull is undoubtedly that of a flathead, and all the identifiable bones are closely similar to those of the modern species *P. bassensis*. Bones of the mouth region have been removed forward of a transverse line just behind the vomerine teeth, so that only the posterior part of the mandible remains, and the posterior portions of one premaxilla and one maxilla. Some of the bones from the left side of the skull are also missing. Breaking and spreading of bones have occurred due to compression.

The atlas and part of the second vertebra, including portions of the neural arches, are attached to the skull. Of the shoulder girdle, portions of the left and right cleithra and the right supracleithrum are present.

The dorsal surface of the cranium is almost flat, with a number of low bony ridges. Most of the suborbital bones are missing, and only an estimate of the diameter of the orbit can be given. The interorbital area is concave, and its width appears to be about three-quarters of the transverse diameter of the orbit.



A	Atlas Vertebra
Art	Articular
Bbr	Basibranchial
Boc	Basioccipital
Br5	Fifth Branchial
Bst	Branchiostegal
Cbr	Ceratobranchial
Ch	Ceratohyal
Cl	Cleithrum
D	Dentary
Ebr	Epibranchial
Eh	Epihyal
Eoc	Exoccipital
Ep	Epiotic
F	Frontal
Hbr	Hypobranchial
Hh	Hypohyal
Hm	Hyomandibular
L	Lacrimal

M	Mesethmoid
Mopt	Mesopterygoid
Mpt	Metapterygoid
Mx	Maxilla
N	Neural Arch
Op	Opisthotic
P	Palatine
Pa	Parietal
Pas	Parasphenoid
Pf	Prefrontal
Phbr	Pharyngobranchial
Pmx	Premaxilla
Pot	Prootic
Pop	Preopercular
Pt	Pterotic
Qu	Quadrate
Sb	Suborbital
Scl	Supracleithrum
Soc	Supraoccipital
Sph	Sphenotic
Uh	Urohyal
V	Vomer

FIG. 1. - Skull of fossil *Platycephalus*, xl.

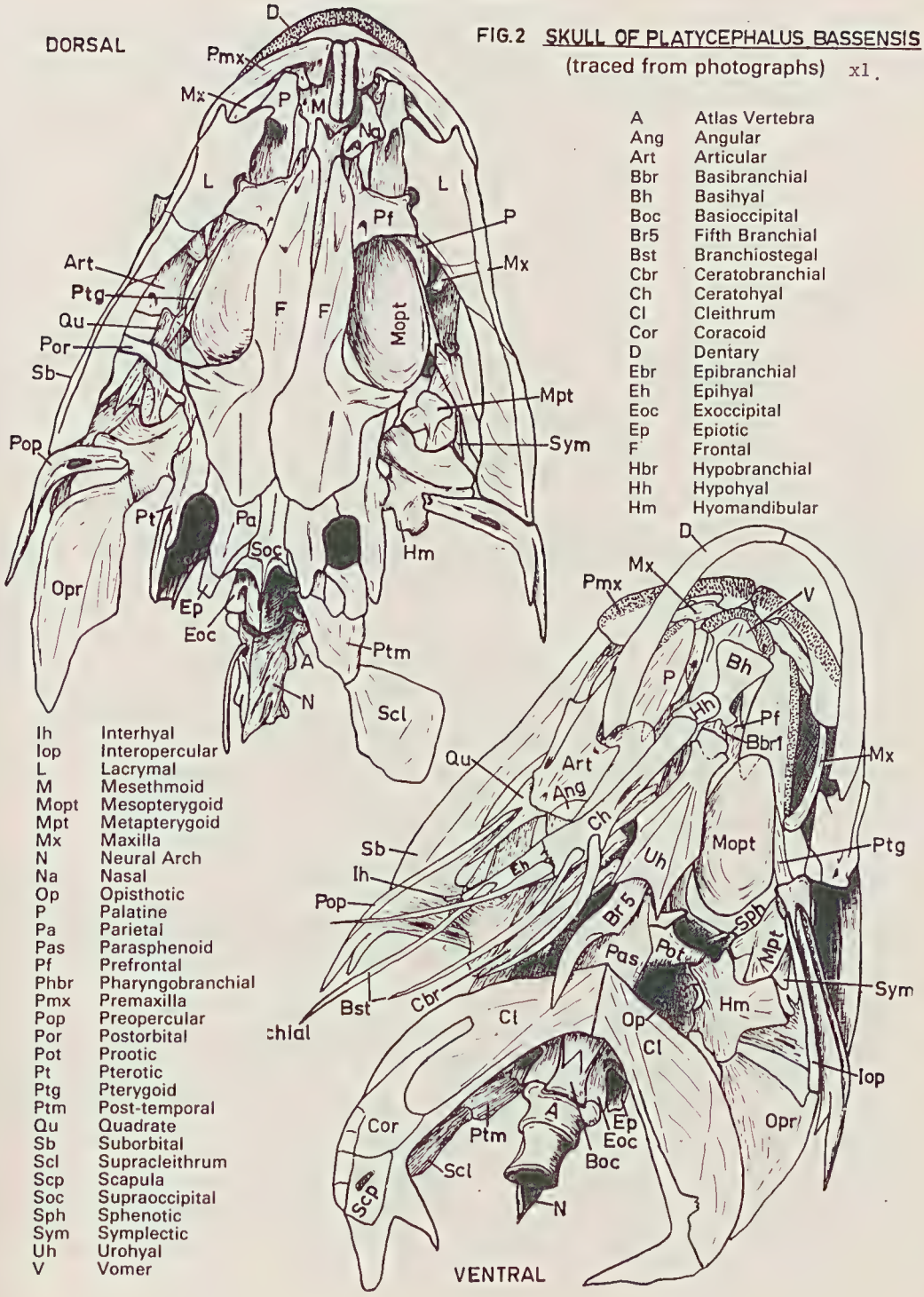


FIG.2 SKULL OF PLATYCEPHALUS BASSENSIS
(traced from photographs) x1.

A	Atlas Vertebra
Ang	Angular
Art	Articular
Bbr	Basibranchial
Bh	Basihyal
Boc	Basioccipital
Br5	Fifth Branchial
Bst	Branchiostegal
Cbr	Ceratobranchial
Ch	Ceratohyal
Cl	Cleithrum
Cor	Coracoid
D	Dentary
Ebr	Epibranchial
Eh	Epihyal
Eoc	Exoccipital
Ep	Epiotic
F	Frontal
Hbr	Hypobranchial
Hh	Hypohyal
Hm	Hyomandibular
Ih	Interhyal
Iop	Interopercular
L	Lacrymal
M	Mesethmoid
Mopt	Mesopterygoid
Mpt	Metapterygoid
Mx	Maxilla
N	Neural Arch
Na	Nasal
Op	Opisthotic
P	Palatine
Pa	Parietal
Pas	Parasphenoid
Pf	Prefrontal
Phbr	Pharyngobranchial
Pmx	Premaxilla
Pop	Preopercular
Por	Postorbital
Pot	Prootic
Pt	Pterotic
Ptg	Pterygoid
Ptm	Post-temporal
Qu	Quadrate
Sb	Suborbital
Scl	Supracleithrum
Scp	Scapula
Soc	Supraoccipital
Sph	Sphenotic
Sym	Symplectic
Uh	Urohyal
V	Vomer

The *supraoccipital* is overlapped on either side by the parietals and anteriorly by the frontals. Its exposed surface is elongated and slightly expanded at either end. It bears a low median ridge for most of the anterior half of its length. A median vertical lamina, the occipital crest, projects down from beneath the body of the bone to meet the exoccipitals above the foramen magnum. The posterior portion of this crest is missing.

The *parietals* are rather flat bones overlying the epiotics and overlapping the supraoccipital to the inside and portion of the pterotics to the outside. They are overlapped anteriorly by the frontals. Each bears a low median ridge. Their posterior ends have been removed.

The *epiotic* bones are almost obscured by the parietals, and have their posterior projections removed.

The *pterotics* are elongated and irregular in shape. The left side bone is almost complete, and the elongated posterior process extends back almost to the level of the end of the exoccipital. A narrow lamina slopes downwards and inwards from this process and connects with the opisthotic. The posterior articular facet for the hyomandibular is present near the anterior of the lateral edge.

The *frontals* are long and narrow, and expand laterally behind the orbits. They have broken apart along the midline suture. The lateral borders project upward and outward in the interorbital region. The line of this border is continued back over the posterior of the bone as a low, gently curved ridge. A number of smaller ridges form almost a radial pattern lateral to this main ridge in the area just behind the orbit. The maximum depth of the bone is beneath the lateral border in the interorbital region.

The *prefrontals* are thick, hollow bones originally sutured to the frontals on the inside and articulating with the lacrymals on the outside. The body of the bone is somewhat rectangular, but the median border is produced forward, to suture with the mesethmoid, and backward, to suture with the outer border of the frontal. The dorsal outline is thus triangular, with the lateral apex truncated to form the articular facet for the lacrymal. The dorsal surface slopes forwards with an arcuate ridge just behind the anterior border. The posterior margin bears a tiny antorbital spine. The dorsal and ventral surfaces are inclined to each other, and the body of the bone is open posteriorly.

The *mesethmoid* (dermethmoid, supraethmoid) is overlapped by the frontals and prefrontals. Two narrow spurs project forward and outward from the dorsal surface, which slopes forward in front of these and is slightly expanded laterally. The anterior portion of the bone has been removed. The anterior borders are in contact with those of the underlying vomer, and a hollow cavity is present between these two bones.

The right *lacrymal* is the more complete, but has been broken into three parts. Portion of the articular facet for the prefrontal has been removed, revealing the hollow region within this facet, which is the thickest portion of the bone. The anterior border is deeply arcuate, and the shaft of the maxilla projects forward from beneath this arc. There are three short spines (preorbital spines) on the anterolateral margins, the third being very small. The posterior portion of the bone is missing.

One *posterior suborbital* is present, though parts of its anterior and lateral borders are missing. It is a thin, flat rectangular bone with a low longitudinal ridge near its lateral margin.

The *palatine* bone present is elongated and rather flat except for an upward-projecting dorsal process near its anterior end, most of which is missing. The bone widens posteriorly and bifurcates near the posterior end, the lateral projection being the longest. A narrow band of small tooth bases is present along the lateral ventral margin, although mostly obscured by the dentary.

The posterior portion of the *premaxilla* which remains is laminar and tapers slightly posteriorly. A band of small, round, uniform tooth bases is present along the lateral ventral margin, portion of which is missing.

The portion of the *maxilla* present is rod-like anteriorly and behind this expands dorsoventrally and a thin, slightly curved lamina projects dorsally from the thickened ventral border.

The *vomer* is a flat, elongated bone covering the anterior margin of the parasphenoid. The anterior end has been removed, and the bone is broken about half way along its length. It bears a shallow, median ventral groove, and appears to taper posteriorly.

The *basioccipital* narrows just in front of the occipital condyle and extends about half way along the floor of the braincase, most of its ventral surface being covered by the parasphenoid.

The *exoccipitals* are present on either side of the basioccipital, their hindmost portions forming the articulating facets for the transverse processes of the atlas. A thin lamina projects upward and inward from each bone to form the lateral boundaries of the foramen magnum.

The *opisthotic* is exposed on the floor of the auditory capsule and slopes upward and outward to connect with the outermost processes of the pterotic. The suture with the prootic is irregular.

The *prootic* bones are visible on the left ventral side of the anterior part of the braincase. An outward-projecting process forms a buttress for the lower half of the anterior hyomandibular facet. Behind the median end of this buttress the bone swells to form a slight saccular bulge, which has been flattened by compression.

The *parasphenoid* is a long, flat bone extending along the base of the skull near the posterior end of the basioccipital forward to the vomer. It is broken in the middle and much of it is concealed. The posterior end bifurcates. It is broadest between the prootics, narrows in front of this, then expands laterally to form a narrow outward-projecting process, as can be seen on the right side. This process is missing on the left side. The bone is narrow in front of this and appears to expand very gradually forward to where it is covered by the vomer.

The posterior portion of the *dentary* which remains is thick and hollow, roughly D-shaped in section, and increasing in diameter posteriorly. The hinder end is deely bifurcated, forming a recess into which the pointed anterior part of the articular projects. The bifurcation is in the horizontal plane and is unequal, the ventral portion being wider and flatter. The narrow dorsal margin, which probably bears teeth, is not exposed.

The *articular* has a very characteristic shape best seen in figure 3. The long pointed anterior part projects into the bifurcated end of the dentary. The posterior end bears a well developed articular facet for articulation with the quadrate.

Both *quadrates* are present, although one was removed during preparation and is

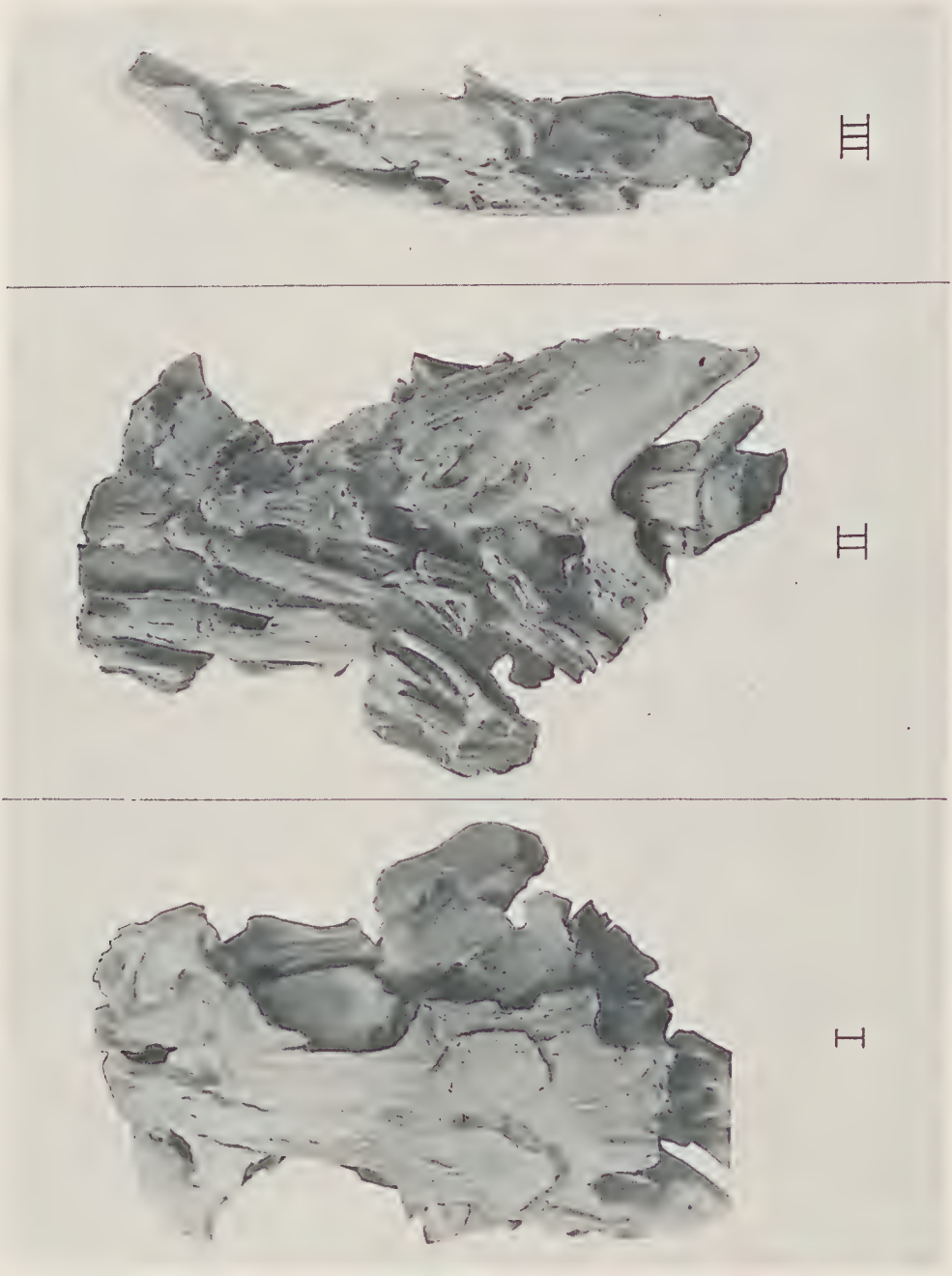


PLATE 1
Figure I - Dorsal view of fossil skull; Figure II - ventral view;
Figure III - right lateral view. All x1.

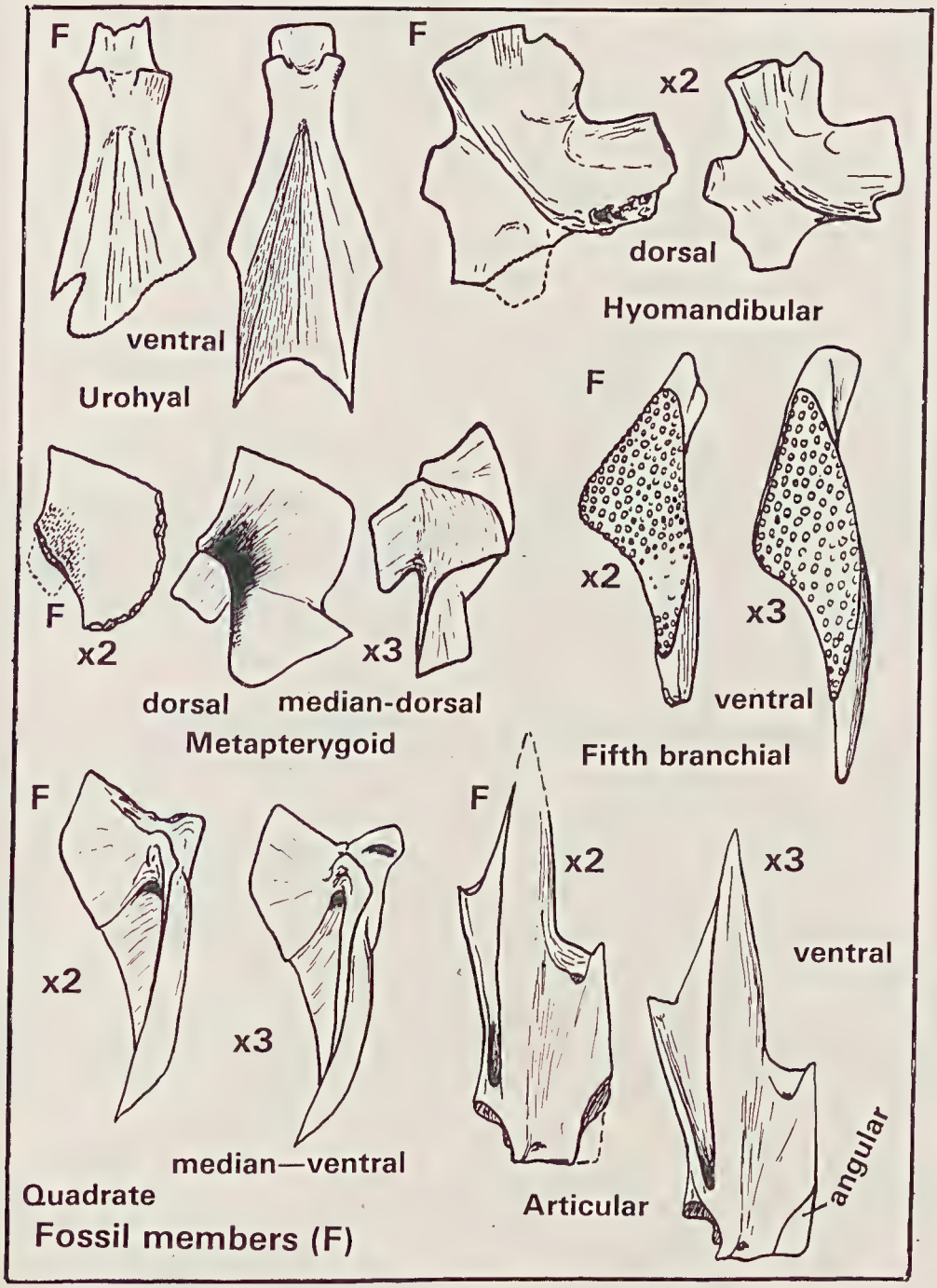


FIG. 3 - Comparison of some fossil and modern bones.

shown in figure 3. The bone has a stout, flat shaft which widens anteriorly to form the articular facet. The ventral surface of this shaft is divided unequally by a low longitudinal ridge which does not reach the anterior end. The inner side of the anterior arm of the preopercular originally sutured along this ridge, and has been moved only slightly from this position. Extending down from the underside of the shaft is a thin lamina of bone which tapers posteriorly.

The *preopercular* is represented only by the anterior arm. This tapers anteriorly to a point, and is incised longitudinally.

Both the *mesopterygoids* (endopterygoids) are present in part, the right one being nearly complete. It is a large, flat, scale-like bone lying beneath the right orbit. The lateral border is straight and slightly thickened, and the bone is widest posteriorly.

Part of a *metapterygoid* is present on the right side of the skull. The upward-projecting dorsal processes, and part of the posterior lamina are missing. The remaining portion is flat and fan-shaped (fig. 3).

The *hyomandibular* is present in almost its original position on the right side of the skull. The articular facet for the pterotic is located at about the middle of the median border (fig. 3). Forward of this, forming most of the anterior border, is the strong anterior articular facet for the prootic and sphenotic. Lateral to this is a thin, broken lamina which originally sutured to an inward-projecting process of the metapterygoid. The thick lateral projection originally was sutured to the inner arm of the preopercular. The posterior border is broken, and the articular facet for the opercular has been removed. The dorsal surface is strongly ridged, while the central surface appears to be smooth.

The *hypohyal* is a short, thick bone of irregular shape. The anterior border is rounded and the median surface is indented.

The *ceratohyal* is roughly oar-shaped, the anterior two-thirds being rod-like while the posterior portion is expanded and flattened laterally, though still fairly thick. The shaft is grooved longitudinally. The *epihyal* is fused tightly to the ceratohyal and tapers posteriorly. A small, rounded facet at the posterior end originally articulated with the interhyal. The ventral surface of the epihyal and the flattened portion of the ceratohyal show a common longitudinal ridge with a shallow groove on either side. The dorsal surface is smooth. The interhyal has not been identified.

Several *branchiostegals* are present on the left ventral side of the skull. These are long, thin, slightly curved bones with small articular facets at their anterior ends. They are flattened rather than circular in section.

The *urohyal* is a large, flat, unpaired bone of characteristic shape (fig. 1, fig. 3). The small anterior lamina partly covers the first basibranchial. Two thickened buttresses are present behind this, and behind these again the bone is almost flat and widens posteriorly, covering the other basibranchials.

Five branchial arches are identifiable. The *first basibranchial* is a small, rounded, equidimensional bone bearing rounded indentations on either side for the articulation of the first hypobranchials. The *hypobranchials* have expanded inner ends merging into the slender, deeply incised form of the long *ceratobranchials*. The posterior *epibranchial* and the two small, rectangular *pharyngobranchials* bear the typical small, closely arranged tooth bases. The fifth branchial arch is represented by a single, rather flat, posteriorly pointed bone (ceratobranchial) which bears teeth over

most of its inner (dorsal) surface (fig. 3).

The *supracleithrum* is a thin, flat bone lying almost vertically at the posterior of the skull (plate 1). Its dorsal border is straight and slightly thickened.

The *cleithra* are large, flat bones which appear to have been sutured together medially. The posterior border is considerably thicker than the rest of the bone.

The *atlas* has a narrow centrum and well developed wing-like transverse processes. Above and just behind these are deep pits in the side of the centrum.

THE SKULL OF *PLATYCEPHALIS BASSENSIS* CUVIER

Since there is little published osteological information on the modern flatheads for comparison, a skull of *P.bassensis* was prepared and a brief description is given here. The specimen was obtained from the Derwent estuary and was donated by Dr M.R. Banks. Figure 2 is traced from photographs. The hyoid and branchial arches have been removed from one side, and the epibranchials, pharyngobranchials and some of the branchiostegals from the other.

The skull is broad and flat, achieving maximum width (65 mm) between the preopercular and tapering forward. The right frontal slightly overlaps the left, and the two form a fairly deeply concave interorbital area, the width of which is about three-quarters the transverse diameter of the orbit. The anterior dorsal process of the palatine lies above the shaft of the maxilla and is sutured to the nasal medially and to the inner arm of the lacrymal. The anterior ends of the premaxilla and maxillae are thickened and have backward-projecting processes. Two small, fused, rod-like bones link the mesethmoid to the premaxillary symphysis. Teeth are borne on the anteroventral surface of the premaxillae and are larger near the symphysis. The dentary is a long, curved bone which tapers anteriorly and bears teeth of fairly uniform size on its rather narrow dorsal surface.

Ventrally, the scale-like mesopterygoid overlaps the posterior part of the palatine, disguising the bifurcated nature of the bone. The vomer is a thin bone which tapers posteriorly and has a band of teeth around its curved anteroventral border. The narrow lamina of bone sutured to the lateral margin of the mesopterygoid, the posterior tip of the palatine and the anterior border of the quadrate lamina is the pterygoid (ectopterygoid). The metapterygoid is sutured to the quadrate lamina and the symplectic laterally and to the hyomandibular posteriorly. The symplectic is a small, flat, elongated, slightly curved bone which widens posteriorly and is sutured to the quadrate, metapterygoid and hyomandibular. The interhyal is a short bone sutured to the end of the epihyal and to the cartilaginous area between the preopercular, hyomandibular and symplectic. The two short buttresses on the urohyal serve for the attachment of short rods of cartilage.

The thin flat bone attached to the operculum and lying inside the preopercular is the interopercular. The lower preopercular spine is nearly twice as long as the upper. Teeth are borne on the posterior pair of eipbranchials and the corresponding pharyngobranchials, and on the under surface of the fifth ceratobranchial.

COMPARISON WITH THE FOSSIL SKULL

A comparison of some dimensions on the two skulls is given below:-

	Fossil	*Modern*	*Ratio Fossil:Modern*
Interorbital width	≈13 mm	11 mm	1.18
Transverse diameter of orbit	≈20 mm	16 mm	1.25
Longitudinal diameter of orbit	25 mm	20 mm	1.25

	Fossil	*Modern*	*Ratio Fossil:Modern*
Width across prefrontals	26 mm	21 mm	1.23
Length from mesethmoid spur to occipital crest	78 mm	61 mm	1.28
Width across sphenotics	31 mm	26 mm	1.19
Length of hyoid bar	54 mm	44 mm	1.23

The dimensions show a fairly constant proportionality, but measurements on a number of modern skulls would be necessary to test the significance of this. The estimated overall body length of the fossil fish, calculated from the relative dimensions of a number of modern *P.bassensis* specimens (Miss L.B. Denne, pers. comm. 1963) is about 0.41 m. This is about the maximum length attained by *P.bassensis*.

The very close similarities between a number of the prominent bones of the two skulls is indicated in Figure 3. Some differences are also apparent, as listed below, but it is possible that these lie within the range of variation of the modern species.

1. The bony ridges on the dorsal surface of the cranium of the fossil are sharper and more pronounced. To some extent this could be due to post-burial solution effects. In arrangement and orientation the ridges are fairly similar, although the curvature of the main supraorbital ridges of the modern skull is more accentuated.

2. The marked overlap of the left frontal by the right on the modern skull is not shown on the fossil. This could be due to breakage and removal of part of the right frontal on the fossil, where the bone has been depressed below the level of the left.

3. The maximum width across the frontals appears to be proportionately greater on the modern skull.

4. The mesethmoid spurs on the fossil are narrower and form a more acute angle.

5. The band of teeth along the ventro-lateral surface of the palatine is narrower on the fossil.

6. The anterior border of the quadrate lamina is slightly thicker on the fossil.

7. The sides of the foramen magnum, as formed by the exoccipitals, are considerably steeper on the fossil.

CONCLUSIONS

The fossil skull is that of a flathead belonging to the genus *Platycephalus* Block 1795, and is strikingly similar to that of the modern sand flathead *P.bassensis*. This suggests there may have been little evolutionary change in the species in the 20 million years or so since the Early Miocene. According to Quilty (1972) the Fossil Bluff Sandstone was deposited in an open marine bay, probably seaward of the mouth of a river - i.e. in the same environment in which *P.bassensis* occurs abundantly today.

ACKNOWLEDGEMENTS

Most of the work on the fossil skull was carried out under the guidance of Dr M.R. Banks while the author was an undergraduate student at the Geology Department, University of Tasmania. The author gratefully acknowledges the many comments and suggestions made by Mr E.O.G. Scott, Dr J.R. Paxton (Australian Museum, Sydney) and Dr Banks.

REFERENCES

Banks, M.R., 1962: Marine Succession, from Cainozoic in Spry, A.H. and Banks, M.R. (Eds): THE GEOLOGY OF TASMANIA. *J. geol. Soc. Aust.*, 9(2): 233-236.

Gregory, W.K., 1951: EVOLUTION EMERGING. MacMillan and Coy., New York.

Quilty, P.G., 1972: The biostratigraphy of the Tasmanian marine Tertiary. *Pap. Roy. Soc. Tasm.*, 106: 25-44.

Papers and Proceedings of the Royal Society of Tasmania, Volume 114, 1980.

(ms. received 1.11.1978)

AQUAGENE VOLCANISM IN THE TASMANIAN TERTIARY, IN RELATION TO COASTAL SEAS AND RIVER SYSTEMS

by F.L. Sutherland
The Australian Museum, Sydney

(with seven text figures and nine plates)

ABSTRACT

SUTHERLAND, F.L., 1980 (31 v). Aquagene volcanism in the Tasmanian Tertiary, in relation to coastal seas and river systems. *Pap. Proc. R. Soc. Tasm.*, 114: 177-199 (incl. 9 plates). ISSN 0080-4703. Australian Museum, Sydney, New South Wales, Australia.

Tertiary aquagene volcanics at over forty localities in Tasmania concentrate in three main regions. The North West Coast - Bass Strait islands examples are mostly related to Miocene high seas. Phreatic tuffs and flow foot breccias erupted from emergent vents (Cape Grim, Trefoil Island, Steep Island, Redpa, Brittons Swamp, Temma, N. Robbins Island and possibly Wynyard). Pillowy lavas represent subaqueous phases of emerging volcanoes (Flat Topped Bluff, S. Robbins Island and Black Pyramid Island). The aquagene volcanics supplement data on levels and depositional depths of Miocene seas and suggest relative levels now up to 110m (early Miocene), 130-140m (early-mid Miocene) and possibly 75m (late-mid Miocene?) above present sea level.

The Mersey-Forth phreatic tuffs and flow foot breccias erupted into dammed sections of leads, successively higher upstream and roughly corresponding to order of eruption from at least six centres (Forth, Paloona, Sheffield, Gads Hill, Borrodaile Plains, Middlesex Plains).

Flow foot breccias formed in Derwent watercourses blocked by earlier flows (Bronte, Great Lake, Waddamana, Wayatinah, Lower Dee, Ouse, Lower Clyde, Meadowbank and Bridgewater). Multiple damming and overtopping is represented at Waddamana and Ouse. Phreatic tuffs erupted from emerging centres (Great Lake, Glenora, Claremont and possibly Plenty).

Zeolitization of aquagene sequences is patchy and most intense near centres of extended activity. Upper Mersey-Forth and Derwent sequences suggest minimum erosion rates of 17-21 and 21-27 m/m.y. respectively over the last 20-25 m.y.

Tasmania provides the best range of Cainozoic aquagene volcanic rocks in Australia, examples elsewhere being sporadic.

INTRODUCTION

Subaerial eruptive rocks dominate Tasmanian Tertiary volcanic successions, but examples of phreatic tuffs and flow foot breccias from aquagene volcanism have been described (Banks 1962a; Sutherland and Corbett 1967; Sutherland 1969; Sutherland and Hale 1970; Sutherland 1973a; 1973b; 1976a; 1976b; 1977a). More complete coastal sequences, with pillow lavas, and inland basaltic leads, with multiple aquagene volcanics, have now been mapped (figure 1) and are described in this paper.

Field work for the present survey was carried out over several trips from February 1971 (Steep Island, Hunter Island), March 1972 (Flat Topped Bluff), April 1972 (Wynyard and Robbins Island), February-March 1974 (Derwent drainage) and

FIG. 1.- Distribution of aquagene volcanics (black dots), Tasmania, with known limits of Miocene marine transgression (dashes).

February-March 1978 (Mersey-Forth drainage). Some aspects of the work on coastal aquagene volcanism were presented at the 45th ANZAAS Congress, Perth, Western Australia.

EMERGENT COASTAL SUCCESSIONS

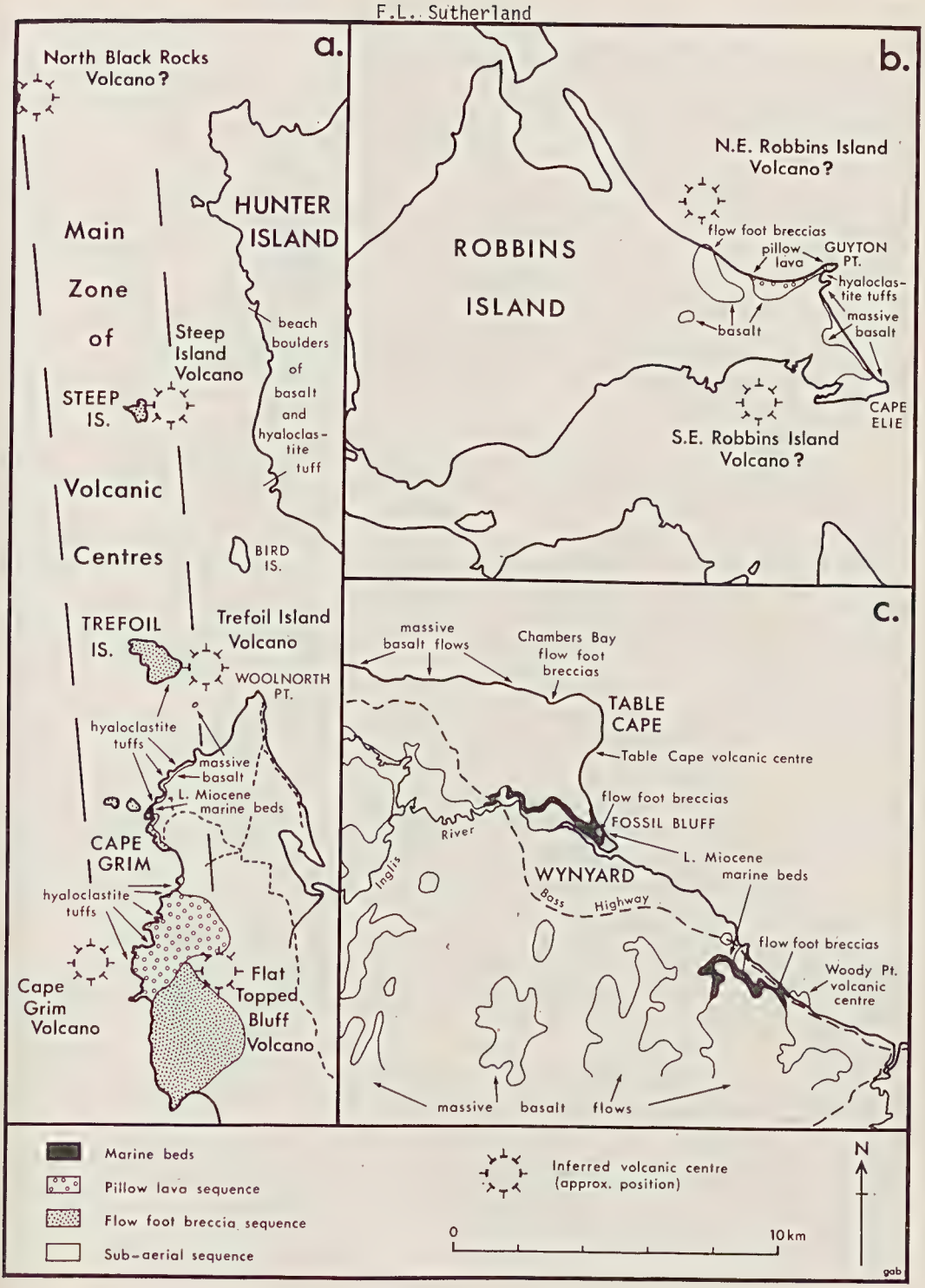
Emergent aquagene volcanic rocks at sixteen sites in coastal north-western Tasmania (figure 2) include sequences with pillowy lavas at Flat Topped Bluff and Robbins Island.

Flat Topped Bluff (Welcome 1:100 000 Sheet 7816)

More complete mapping (figure 3) necessitates reinterpretation of earlier work (Studland Bay Basalts; Sutherland and Corbett 1967). Northern pillowy and columnar lavas are overlain southwards by flow foot breccias, with capping subaerial lavas. The pillowy lavas overlie bedded tuffs and massive basalt with no exposed lower contact (Plate 1).

Basal tuffs and basalt. Tuffs up to 10 m thick partly intercalate with and

FIG. 2.- Distribution of aquagene volcanics, volcanic centres and marine beds, north-western Tasmania (a) Woolnorth and off-shore islands, (b) Robbins Island, (c) Wynyard district. Figure opposite.


a.
North Black Rocks Volcano?
HUNTER ISLAND
Main Zone of Volcanic Centres
Steep Island Volcano
STEEP IS.
beach boulders of basalt and hyaloclastite tuff
BIRD IS.
TREFOIL IS.
Trefoil Island Volcano
WOOLNORTH PT.
hyaloclastite tuffs
massive basalt
L. Miocene marine beds
CAPE GRIM
hyaloclastite tuffs
Cape Grim Volcano
Flat Topped Bluff Volcano
b.
N.E. Robbins Island Volcano?
ROBBINS ISLAND
flow foot breccias
pillow lava
GUYTON PT.
hyaloclastite tuffs
massive basalt
basalt
CAPE ELIE
S.E. Robbins Island Volcano?
c.
massive basalt flows
Chambers Bay flow foot breccias
TABLE CAPE
Table Cape volcanic centre
flow foot breccias
FOSSIL BLUFF
L. Miocene marine beds
WYNYARD
Bass Highway
Inglis River
flow foot breccias
Woody Pt. volcanic centre
massive basalt flows
Marine beds
Pillow lava sequence
Flow foot breccia sequence
Sub-aerial sequence
Inferred volcanic centre (approx. position)
0
10 km
N
gab

disconformably underlie the pillowy lava. Closely bedded vitric tuffs, with some cross-bedding, predominate and show localized fault drags, contorted bedding, load casting, clastic dykes and autobrecciation. Coarser alternation of lapilli tuffs, between 0.05 and 0.3 m thick (Grid ref. 7816-043906) are cemented with secondary minerals and contain sporadic fragments of scoriaceous basalt.

The basal basalt is blocky columnar to platy with radiating joints. Abundant quartzite and vein quartz inclusions up to 0.45 m across (Grid ref. 7816-038901) suggest underlying Precambrian basement (Plate 2). The flow is folded with the tuffs (Plate 1) into anticlinal domal structures with limbs dipping up to 40° (Grid refs 7816-046914, 051922).

Pillowy and columnar flows. These lavas, up to 100m thick, are exposed in shore-line cliffs. Entrail-like pillow lavas grade into pillowy sheets and interspersed lenses of massive columnar basalt. Pillows up to 10m long range from 0.3 to 1.2m across, with amygdales of zeolites, carbonates, clay and silica, and interstices may contain hyaloclastite tuff.

Pillowy flow sheets up to 20m wide and 1.5m thick mould underlying pillow lava. More massive flow sheets up to 5m thick pass into 'mega pillows' (Plate 3) and elongate lenses of massive columnar basalt reach 10m in thickness. Pillowy structures suggest flow from a north-north-easterly direction.

Flow foot breccias. These form steep cliffs, but were examined where they overlie pillowy lavas. South of Hippo Point larger pillow fragments lie in a coarse fragmentary to finer tachylytic matrix, cemented by carbonate and zeolite and including rare fragments of vitric tuff. Crude bedding dips mostly 20-40° south-westerly but swings south-easterly at Bluff Point. Here beds rich in flow foot fragments succeed more fragmented finer grained beds containing blocks of amygdaloidal basalt derived from underlying pillowy flows.

Capping flows. Massive subhorizontal basalts, at least 6 to 20m thick, are poorly exposed under soils and wind blown sands, but show a strongly scoriaceous base above 80m elevation.

Eruptive history. The tuffs above the basal flow represent phreatic eruption into shallow water. They resemble tuffs showing easterly regional dips under north-easterly dipping flow foot breccias and interbedded basalt conglomerates around Cape Grim and Slaughter Bluff (Sutherland and Corbett 1967). They are coarsest at Flat Topped Bluff, suggesting an offshore vent for the Cape Grim volcano north-west of Flat Topped Bluff (figure 2a).

Deformation of these basal units preceded or accompanied eruption of pillowy lavas from a subaqueous vent north-east of Flat Topped Bluff. Minor tuffs within pillowy sequences suggest phreatic emergence before subaerial flows from a southerly breach built a delta of flow foot breccias into surrounding waters and then capped a 'tuya' volcano.

The Flat Topped Bluff volcano appears to partly post-date the Cape Grim volcano and petrographically is mildly alkaline or transitional olivine basalt compared to more tholeiitic olivine basalt from Cape Grim.

These aquagene volcanic rocks suggest eruption into waters relatively at least 80m and possibly up to 110m above present sea-level. They contain no micro-fossils to characterize marine or non-marine deposition (P.G. Quilty, pers. comm.), but are overlain by latest Oligocene - early Miocene marine beds of the Cape Grim transgression (Quilty 1972; Sutherland 1973a).

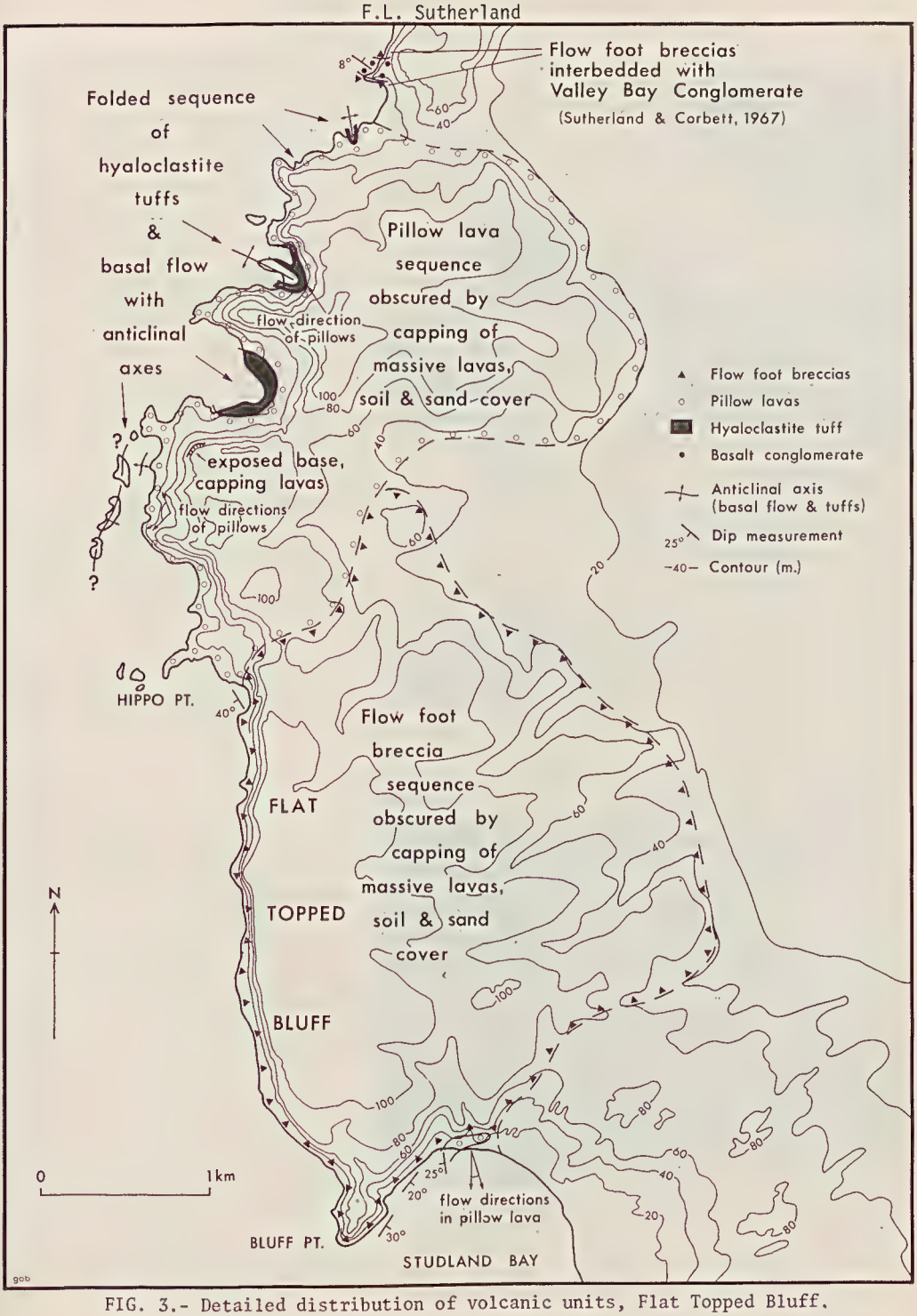

Flow foot breccias interbedded with Valley Bay Conglomerate
(Sutherland & Corbett, 1967)
Folded sequence of hyaloclastite tuffs & basal flow with anticlinal axes
Pillow lava sequence obscured by capping of massive lavas, soil & sand cover
flow direction of pillows
exposed base, capping lavas
flow directions of pillows
HIPPO PT.
Flow foot breccia sequence obscured by capping of massive lavas, soil & sand cover
FLAT TOPPED BLUFF
BLUFF PT.
STUDLAND BAY
flow directions in pillow lava
Flow foot breccias
Pillow lavas
Hyaloclastite tuff
Basalt conglomerate
Anticlinal axis (basal flow & tuffs)
Dip measurement
Contour (m.)
N
0
1km

FIG. 3.- Detailed distribution of volcanic units, Flat Topped Bluff.

PLATE 1.- Anticlinal dome formed by basal basalt extending into sea (right) and flanked by dipping beds of tuffs exposed in coves (lower left), with overlying pillowy lavas forming promontories (upper left and lower right). North end Flat Topped Bluff, 1 km south-west of Valley Bay, looking west-south-westerly.

Robbins Island (Circular Head 1:100 000 Sheet 7916)

Aquagene lavas are associated with fine-grained, laminated vitric tuffs (figure 2b). South of Guyton Point (Plate 4) tuffs below pillowy lavas show small scale current and normally graded bedding, gentle warping and soft sediment deformation. At Little Bluff, Ransonnet Bay, tuffs are thinly interbedded with zeolitized flow foot breccias and dip 10° south-south-easterly (Plate 5).

Pillowy lavas. These resemble 'megapillows' (Plate 6) and reach 40m in thickness between Big Bluff and Guyton Point. They include minor hyaloclastite breccia and flow directions dip shallowly north north west-to east-north-east.

Massive lava. Platy jointed basalt extends south of Guyton Point from a gentle domal structure to Cape Elie where fragments of coarse sub-aerial (?) tuff appear amongst basaltic beach boulders.

Eruptive history. The pillowy and massive lavas are petrographically similar alkali olivine basalt containing small lherzolitic xenoliths. They contrast with flow foot breccias at Ransonnet Bay, which are highly altered, but more saturated olivine basalts.

The evidence suggests separate centres of eruption north-east and south-west of Robbins Island (figure 2), partly erupting into waters relatively 20-40m above present sea-level. Pillowy lavas, structurally and petrographically similar to Robbins Island examples outcrop further east on Circular Head Peninsula (P.W. Baillie, Tasmanian Mines Department, and author's observations), but flowed from the east and are unlikely extensions for Robbins Island.

PLATE 2.- Basal basalt flow containing abundant inclusions of Precambrian quartzites, shore exposure, north west side Flat Topped Bluff, 0.75 km north of Hippo Point.

Coastal Marine Aquagene Volcanism

Earliest Miocene marine beds (figure 2a, b) overlie flow foot breccias at Cape Grim and underlie those at Fossil Bluff and Woody Point, Wynyard (Sutherland and Corbett 1967; Quilty 1972). Eruption is indicated into Early Miocene seas standing at least

75-80m above present sea-level and possibly up to 110m if Flat Topped Bluff volcano grew in coeval seas. These levels agree with estimates (71-106m) using maximum depositional depths of Miocene marine sedimentation (Quilty 1972).

Early to mid-Miocene marine beds (early Longfordian to Batesfordian) occur with aquagene volcanics at Marrawah-Redpa and Brittons Swamp, but relative ages were uncertain (Sutherland & Corbett 1967; Quilty 1972). An older age was based on basalt fragments in the limestones, but Quilty placed the basalts above the sediments and explained the fragments by distant transport. Subsequent examination confirms Quilty's placement and shows that the bulk of basalts are flow foot breccias erupted into Batesfordian seas over 106-130m above present level; this agrees with sedimentational depths (125-140m; Quilty 1972). The basalt fragments in Batesfordian limestone, however, petrographically match the overlying basalts and have a glassy altered mesostasis unlikely to survive prolonged transport. They may derive from initial eruptions, prior to deltaic extension of Batesfordian flow foot breccias. Higher temperature zeolitization, which developed tacharanite, near a basalt intrusion at Linnanes Road quarry, Bass Highway (Sutherland 1976b) and in phreatic tuffs north of Seymour Hill suggest eruptive sources for flow foot breccias.

Mid-Miocene marine sediments at Temma (Balcombian?; Banks 1962b) lie near weathered flow foot breccias and massive capping basalt, suggesting eruption into a sea 75m above present level.

Aquagene Volcanic Islands

Aquagene volcanic rocks off north-western Tasmania resemble coastal occurrences and their wide distribution in Bass Strait favours marine associations (figures 1 and 2).

West-dipping flow foot breccias and coarser phreatic tuffs at Trefoil Island (Sutherland and Corbett 1967) suggest eruption from a vent to the east into seas 80m above present level.

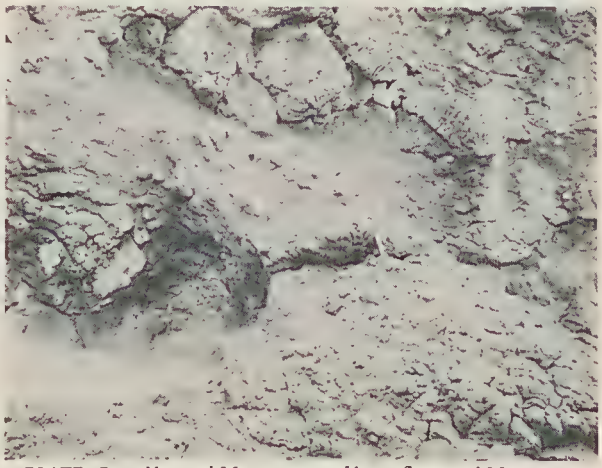


PLATE 3.- Megapillow extending from pillowy lava, shore line north-west side Flat Topped Bluff, 0.75km north of Hippo Point, looking eastwards.

Steep Island, circumnavigated by plane and boat, showed flow foot breccias dipping westerly on the north-west side. Massive basalt, flow foot breccias and vitric tuff form beach debris on the western shore of Hunter Island facing Steep Island. This suggests an offshore aquagene vent (figure 2). The flow foot breccias were photographed and sampled on Steep Island by Miss Sandra Bowdler, Australian National University and like most Hunter Island debris are petrographically olivine tholeiites. Exceptional shore boulders of coarse alkali basalt from Hunter Island resemble Mt Cameron West basalt, 30km to the south, but transport from that area is unlikely and they probably come from nearby submerged outcrops.

Aerial inspection identified flow foot breccias forming prominent rocks west of Steep Island (North and South Black Rock) and contrary dips suggest more than one centre. These fall on north north westerly alignments with coastal centres (Flat Topped Bluff, Cape Grim, Trefoil Island, Steep Island and North Black Rock), probably reflecting control by basement faulting (figure 2).

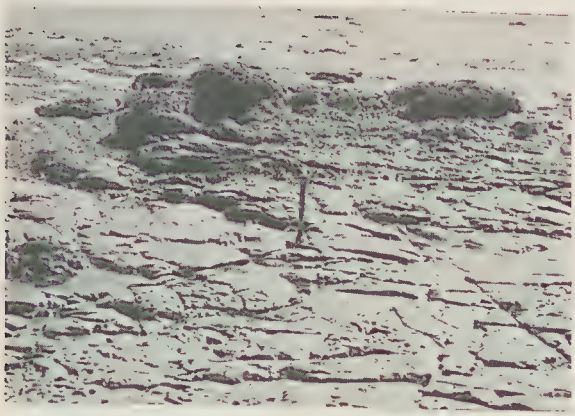


PLATE 4.- Jointed bedded tuffs (foreground) underlying pillowy lava, Guyton Point, Robbins Island.

Photographs of Black Pyramid Island, taken during a rare landing (Green and Macdonald 1963), reveal apparent aquagene structures. The lower 30m resembles the pillowy and columnar flows of Flat Topped Bluff volcano and is overlain by about 3m of near-horizontal beds resembling outcrops of vitric tuffs from Cape Grim and Trefoil Island volcanoes. A 40m thick capping of flow foot breccias dips northerly and suggests eruption from the south into seas over 73m above present level. If identified correctly, this sequence represents classic emergence of a subaqueous vent.

Volcanism and Miocene Seas - Coincidence of aquagene volcanics and marine deposits in north-western Tasmania supplements evidence of high Miocene sea-levels in Bass Strait. It supports sedimentation depths determined from fossils (Quilty 1972), giving seas up to 110m (Early Miocene) and 130-140m (Mid-Miocene) above present level.

Absence of marine aquagene volcanics elsewhere in Tasmania may reflect several factors. The other coastlines are more dominated by resistant dolerites, granite and older Precambrian blocks that may have barred marine incursion. Some potential inlets for marine encroachment were already blocked by thick basalt fills prior to Miocene marine transgression and some early Miocene marine inlets may have become blocked by basalts erupted during erosional hiatus in sedimentation, forestalling later marine incursion. Subaerial lavas fill valleys in Early Miocene marine beds to below sea-level at Cape Grim-Woolnorth, Mt Cameron West and Table Cape. Sedimentation breaks in the Australian marine record occur in mid-Early Miocene and post-Middle Miocene times (Quilty 1977), so that dating of basalt fills are needed to assign them to a particular hiatus.

PLATE 5.- Flow foot breccias interbedded with finely-bedded tuffs, dipping south, foreshore 4km west of Guyton Point, Little Bluff, Ransonnet Bay, Robbins Island.

Absolute levels of Miocene seas based on present heights of marine beds and aquagene volcanics are uncertain due to possible later tectonic movements. Quilty (1972) considered that differences in heights of deposits from north-western to north-eastern Tasmania reflected eastward downtilting, but other factors may apply as faunal units range over 80m in thickness and may be transgressed by aquagene volcanism and erosional breaks. Benching between 60-75m above sea-level on King Island and Flinders Island, Tasmania (Jennings 1959; Kershaw and Sutherland 1972) probably mark old sea-levels. These

match the youngest (?) Miocene marine level at Temma (75m) and if related do not support significant post-mid Miocene eastward downtilting. Indeed, there is evidence of some relative uplift of Tasmania since the Last Interglacial with maximum rates in the north-eastern sector (Colhoun 1978).

INLAND BASALTIC LEADS

Aquagenic volcanics have been recognized in the ancestral Mersey-Forth (Sutherland 1976b) and Derwent River systems (Banks 1955; Anandalwar 1960; Sutherland and Hale 1970; Sutherland 1973b, 1976a, 1977a) and pillowy contacts were described from lava infilling wet sediments in the ancestral Tamar River (Sutherland 1971).

Mersey-Forth Leads (figure 4)

Basaltic breccias, agglomerates and tuffs up to 150m thick in Oligocene-Miocene leads under Borrodaile Plains and Gads Hill (Spry 1958), near Moina (Paterson 1967) and at Paloona (Burns 1964) were thought to indicate nearby centres, but are aquagene volcanics not necessarily formed close to a vent.

Basalt remnants and silicified sub-basaltic sediments suggest at least 300m of incised relief in upper leads (Jennings 1963; Rawlings 1967) and more subdued relief around 200m in lower leads (Burns 1964). The eruptive history, location of centres, drainage dislocations and burial depths are revised from examination of sections in several leads. Initial lead positions (figure 4) are approximate and would change during volcanism.

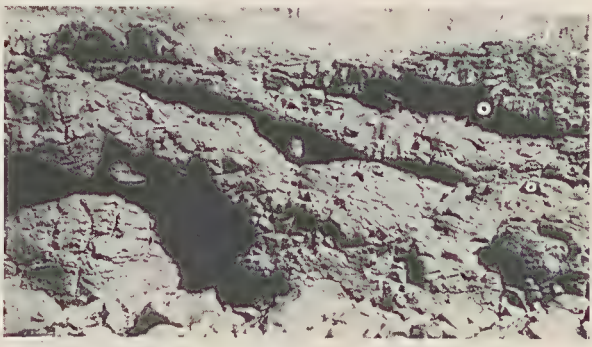


PLATE 6.- Pillowy lava (side view) dipping seawards to the north-east, foreshore west of Guyton Point, Ransonnet Bay, Robbins Island.

Lorinna-Liena Leads (Mersey 1:100 000 Sheet 8144). Massive flows fill the gutters of these leads - poorly exposed near Lorinna between 430-540m above sea-level, but well exposed in a thick flow in Ration Tree Creek between 390-490m (east Liena Lead). At least three flows occur on Lemonthyme Road between 440-550m (south Lorinna Lead). The highest overlies fine-grained inter-basaltic sediments (520-540m) along an irregular intrusive pillowy contact dipping north-west and underlies soft unsorted sediments which contain blocks of basalt and dip up to 25° north, but become rarer in basalt fragments and subhorizontal towards the top. The beds contain altered horizons and may represent old partly weathered fluvial or landslip deposits.

Gads Hill volcano. The lower flows and sediments are followed by fine-grained vitric tuffs, exposed in a 3m cliff above 540m elevation, 2km south east of Lorinna (Grid ref. 8114-DP295992) and in the Ration Tree Creek section, where 0.1m of tuff at 495m elevation underlies tachylytic agglomerate in Shaws Creek. The agglomerate dips over 35° south-west and contains fragments of basalt, Ordovician limestone, rare dolerite, chert and vein calcite up to 15cm across in zeolitized tachylytic matrix. It grades up into massive fine basaltic agglomerates and coarse tachylytic tuffs to over 550m elevation. These horizons resemble phreatic deposits and probably erupted from a partly submerged vent east of Gads Hill, as they do not appear in Lemonthyme Road south of Gads Hill.

Flow foot breccias form prominent cliffs (Plate 7) south of Ration Tree Creek,

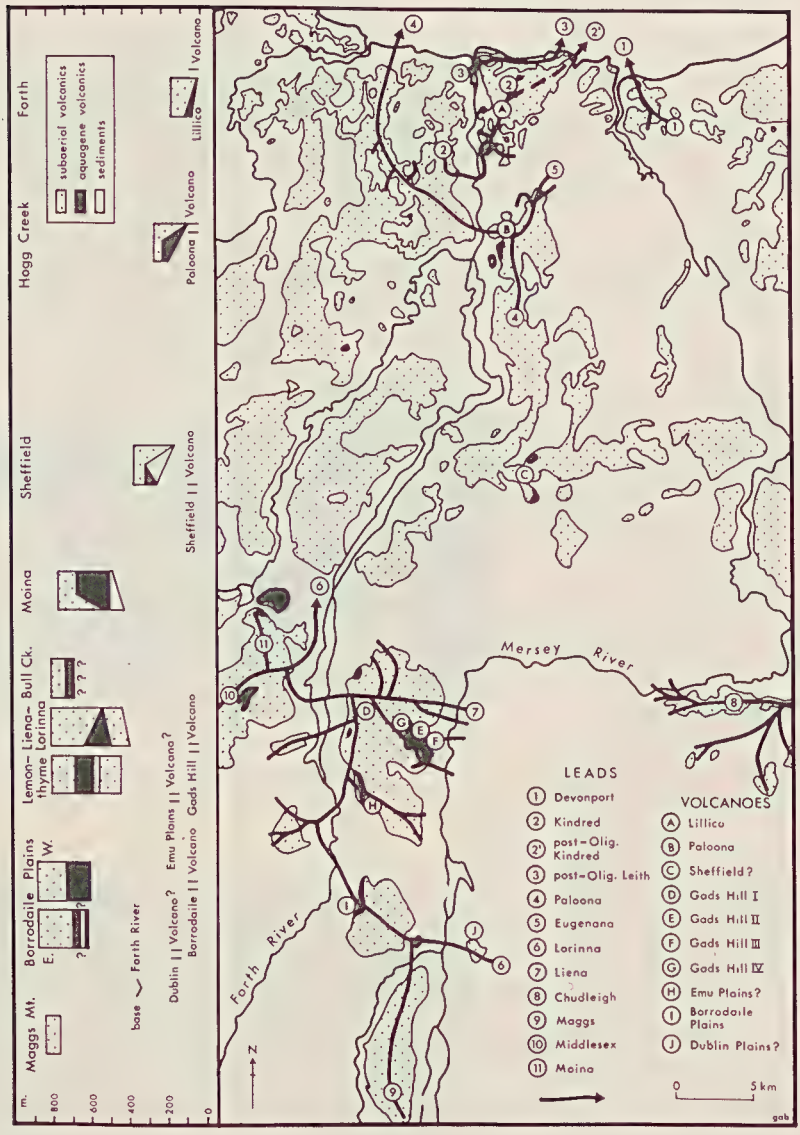


FIG. 4.- Distribution of aquagene volcanics (black areas) and volcanic centres (lettered circles) in relation to deep leads (numbered circles) of the ancestral Mersey-Forth drainage (after Jennings 1963 and Burns 1964). Volcanic sections with aquagene volcanics, showing relative elevations and thicknesses, are shown opposite their projected geographic position on the map.

where they dip 20-25° westerly, but are disfigured by landslips on the north side. They are capped by massive scoriaceous to columnar flows from 620m to over 800m elevation on Emu Plains. Massive basalt with a vertical to bulbous lateral contact cuts the breccias on Olivers Road (Grid ref. 8114-DP324988) and may form a feeder dyke for a capping flow.

The Ration Tree Creek section is strongly zeolitized (Sutherland 1965, 1976b) and secondary minerals will be detailed elsewhere. The species and habits would require burial depths around 700-1500m to form, but as zeolitization is irregular in the Upper Mersey-Forth sequences and overtopping into the Mole Creek Valley is not substantial (Jennings 1963), it more likely reflects elevated temperatures during late-stage extrusion from the Gads Hill volcano.

A four stage growth is suggested for this volcano (figure 5).

a) subaerial lavas blocked the Lorinna-Liena Leads north of Gads Hill, damming the Liena Lead.
b) phreatic eruption of tuffs and breccias further ponded the drainage into a substantial lake.
c) eruption of subaerial lavas into the lake built a delta of flow foot breccias westwards.
d) overtopping of the lake by subaerial lavas fed from dykes and late stage zeolitization around the centre.

The distribution of the volcanics suggests fissure-like growth (figure 5), possibly with some east-south-easterly migration of activity, and location on a north-westerly trending basement fault extending from Moina (Jennings 1963).

Emu-Borrodaile Plains volcanoes

Flow foot breccias in Lemonthyme Road near Addison Creek are stratigraphically higher (580-675m elevation) and unrelated in dip to Ration Tree Creek breccias. The lowest breccias (580-600m elevation) overlie and partly intrude fine-grained mudstone and minor hyaloclastite tuff. Pillowy intrusive tongues (Plate 8) dip north-north-westerly up to 25°, a similar attitude to underlying boulder beds and flow. This suggests a source under Emu Plains which changed to aquagene volcanism, probably from damming of the southern Lorinna Lead by growth of the Gads Hill volcano.

The highest Lemonthyme Road breccias (600-675m elevation) dip up to 40° north-north-easterly to north-easterly. This suggests eruption into the ponded Lorinna Lead from a further upstream source, probably near Borrodaile Creek, where 120m of zeolitized tachylytic tuffs and overlying flow foot breccias are exposed in landslips. Growth of this Borrodaile volcano would dam higher drainage and build the aquagene volcanics to elevations of 720m.

Unzeolitized flow foot breccias, 15m thick, dip south westerly below Borrodaile Plains around 620m elevation in the Mersey-Arm junction road (Grid ref. 8114 DP-331853), above 10m of massive basalt and sub-basaltic sediments. The lowest basalts in the section, they appear unconnected to the Borrodaile centre, but may relate to flows between 600-760m elevation east at Dublin Plains (Ford 1960). Eruption from Dublin Plains into the Lorinna-Maggs Lead junction could explain the limited damming and breccia flow direction.

Unzeolitized flow foot breccias at 660m elevation, dipping north from the Lorinna junction, 1 km south of Machinery Creek on Olivers Road, may represent flows that descended from upstream leads and backed into earlier dammed sections of Liena Lead.

Maggs Lead (Mersey 1:100 000 Sheet 8114)

Flows capping Maggs Mt above 760-880m elevation may be upstream continuations

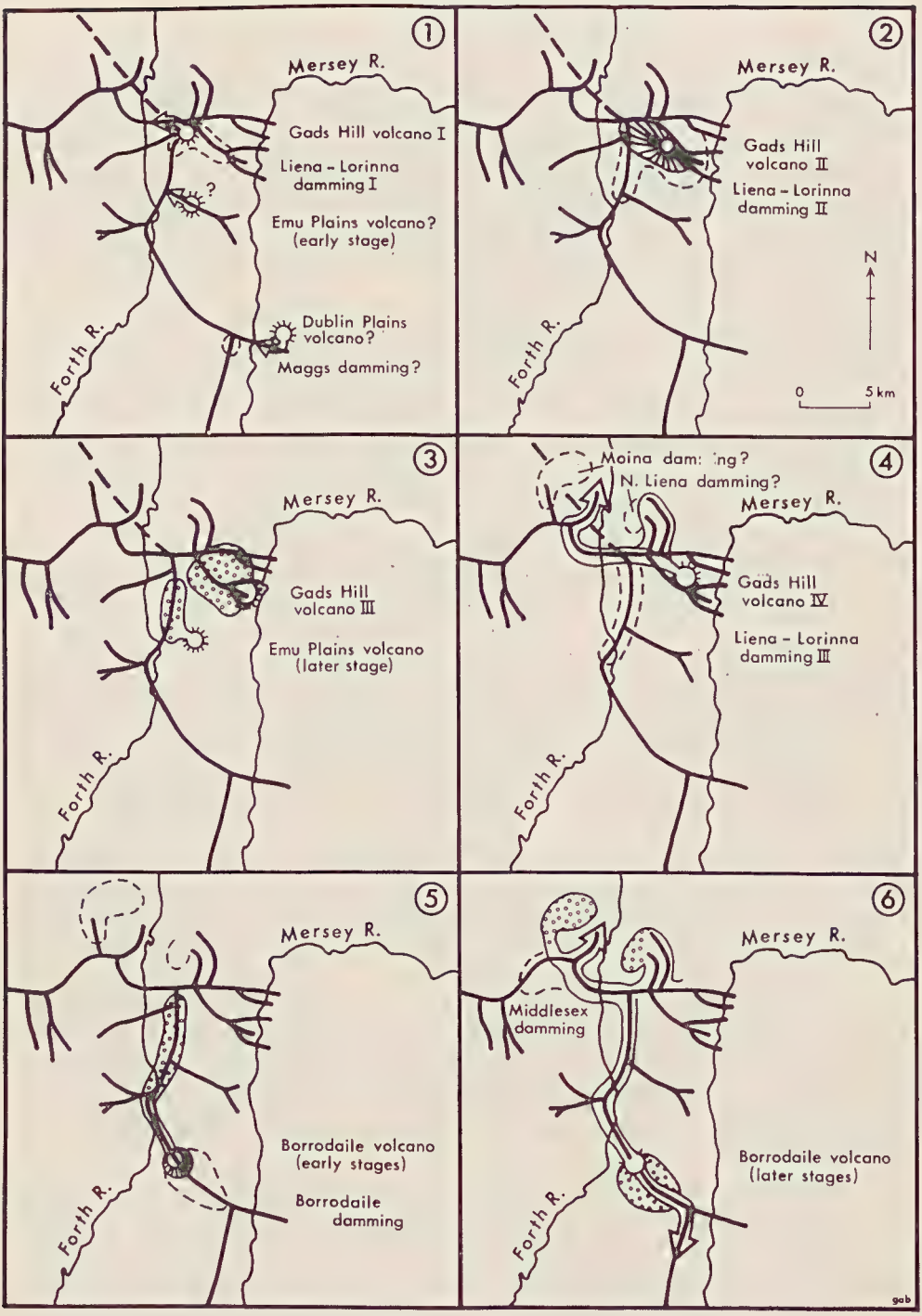

1
Mersey R.
Gads Hill volcano I
Liena - Lorinna damming I
?
Emu Plains volcano? (early stage)
Dublin Plains volcano?
Maggs damming?
Forth R.
2
Mersey R.
Gads Hill volcano II
Liena - Lorinna damming II
N
0
5 km
Forth R.
3
Mersey R.
Gads Hill volcano III
Emu Plains volcano (later stage)
Forth R.
4
Moina dam: ing?
N. Liena damming?
Mersey R.
Gads Hill volcano IV
Liena - Lorinna damming III
Forth R.
5
Mersey R.
Borrodaile volcano (early stages)
Borrodaile damming
Forth R.
6
Mersey R.
Middlesex damming
Borrodaile volcano (later stages)
Forth R.
gab

FIGURE 5

from Borrodaile Plains (Spry 1958). Zeolitization in the basal Maggs succession, away from known centres, belongs to the top of the chabazite zone, usually developed under 200-700m of burial. This suggests less than 80-580m stripped from Borrodaile-Maggs successions.

The Forth River lies at 340-360m elevation relative to the present basalt top at 880m and estimated Miocene top between 960-1420m. This gives average lowering of 21-27m/m.y.(min.) to 43-54m/m.y.(max.) over the last 20-25 m.y. This exceeds average lowering for Tasmania (10-15m/m.y.) since burial of Jurassic dolerites (Sutherland 1977b), but is expected after late Mesozoic/early Tertiary epeirogeny.

Middlesex-Moina Leads (Forth & Mersey 1:100 000 Sheets 8115 & 8114)

These leads joined the Lorinna Lead (Jennings 1963). The Moina Lead contains basalt breccias associated with Early Miocene sediments above 490m elevation (Paterson 1967). The breccias reach 660m elevation on Cradle Mountain Road and are unzeolitized with south-westerly to south-easterly dips. Massive basalts occur down from Moina to 540m elevation 0.75 km along Lake Gairdner Dam Road where they are updragged (?) against easterly-dipping sands overlying Ordovician sandstones.

The breccias suggest a dammed Moina lead, either blocked locally or by flows in the Middlesex or Lorinna Leads, before overtopping with lavas to over 760m elevation. Absence of phreatic tuffs and zeolitization favours distant sources for the breccias.

Flow foot breccias, over 40m thick, underlie massive lavas at 720m in the Middlesex Lead at Bull Creek. Mildly zeolitized, they dip easterly from an upstream source and are the highest breccias found in the Mersey-Forth Leads. They may owe their elevation to damming of the Lorinna Lead by the Borrodaile flows.

Paloona-Kindred Leads (Forth 1:100 000 Sheet 8115)

The ancestral Forth probably flowed into Bass Basin via Paloona and Kindred Leads (Burns 1964). The oldest flows under Miocene (?) sediments petrographically match late Eocene-early Oligocene alkali basalts and olivine nephelinite in the adjacent Devonport Lead (Sutherland 1973a).

Forth volcano. 'Pyroclastics' are common in the Don-Forth interfluve (Burns 1964). Tachylytic lapilli tuffs are interbedded with flows south of Lillicos Beach (Grid ref. 8115-DQ400423) and flow foot breccias extend from 50-75m elevation below Forthside Hill in Fulton Creek down to 15m elevation 0.5 km east of Forth Post Office. The tuffs rest on alkali basalt but petrographically resemble the flow foot breccias and olivine tholeiite flows that extend north east to 40m high cliffs at Don Heads.

The Fulton Creek breccias, zeolitized with tacharanite, suggests a nearby centre between Lillico and Forth, which dammed upstream drainage. The capping flows diverted the Paloona Lead westwards and developed the post-Oligocene Leith Lead across the old Kindred Lead. The new Kindred Lead shifted eastwards and post-Oligocene flow fillings can be traced from Forthside Hill to Don Heads.

Paloona-Sheffield volcanoes. Gorge-blocking agglomerate in Hogg Creek (Burns 1964) is flow foot breccia formed after initial damming by flows downstream of Paloona. Vitric

FIG. 5.- Tentative reconstruction of volcanic history, Upper Mersey-Forth Leads (strong lines) from initial eruption of flows into the Liena-Lorinna Leads up to filling of the Maggs Lead and damming of the Middlesex Lead (1-6), with volcanic vents (hachured circles), valley filling flows (symbolic arrowed directions, not showing flow into all tributaries), approximate limits of upstream damming (dashed areas), phreatic cones (shaded deposits), flow foot breccias (open dotted areas) and major fault (strong dashed line).

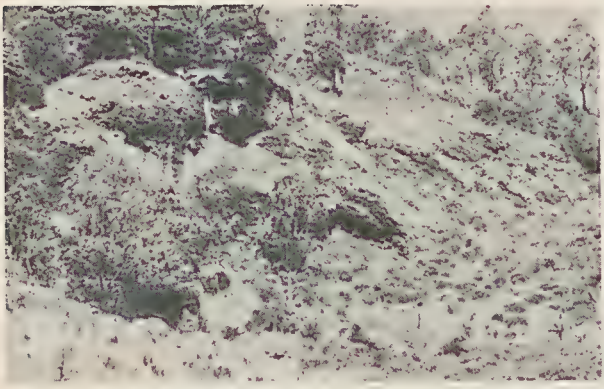


PLATE 7.- Cliffs of flow foot breccias, dipping westwards under capping lavas, south side Ration Tree Creek above Olivers Road, Upper Mersey Valley. Underlying tuffs form the poorly exposed foreground.

tuffs above Tertiary sands in the Eugenana Lead (Burns 1964) may represent phreatic emergence of the Paloona volcano. The breccias at 80-200m elevation east of Hogg Creek dip north-north-easterly to west-south-westerly and converge on a focus about 1.5 km south of Paloona. They are moderately zeolitized, but further upstream west of Hogg Creek, between 180-200m elevation in Paloona Power Station road cuts, breccias under capping flows (Plate 9) are unzeolitized.

The Paloona centre erupted olivine tholeiites, but other flows in the Lead include alkali basalts. The higher flows extensively dammed the Lead to form Lake Sheffield and its sediments reach 300m elevation south of Sheffield.

Flow foot breccias overlie Lake Sheffield sediments in poor exposures on Claude Road and in abandoned railway cuts 2-3 km south-west of Sheffield. They are olivine tholeiites and fresh specimens from railway excavations donated to the Queen Victoria Museum, Launceston, in 1914 are strongly zeolitized with development of tacharanite. This suggests eruption into southern Lake Sheffield from a nearby centre.

Mersey-Forth Aquagene Volcanism

Aquagene volcanics in Mersey-Forth Leads relate to six and possibly eight or more centres (figure 5). Flow foot breccias suggest waters up to 120m deep, backing upstream up to 15 km from blockages. Breccias lie successively higher upstream (figure 5), corresponding roughly to order of eruption, with pre-Miocene breccias in the lower Kindred and Paloona Leads and Miocene breccias in the higher Lorinna, Liena, Moina and Middlesex Leads.

PLATE 8.- Pillowy lava bulbs and tongues intruding sediments and dipping north-easterly, Lemonthyme Road, south of Addison Creek, Upper Forth Valley.

Most aquagene centres erupted olivine tholeiites. In the Upper Mersey-Forth lower flows include alkali and transitional basalts, but with vigorous growth of Gads Hill and Borrodaile volcanoes initiating aquagene activity, tholeiitic basalts appear and dominate the capping lavas (petrologic examinations; Spry 1958 and this study).

Zeolitization in the Mersey-Forth basalts is patchy, becoming more intense with higher temperature associations around large centres with several eruptive phases (Gads Hill volcano). Away from eruptive centres, low grade zeolitization may develop by burial in thicker sequences (Maggs Mt).

Other Aquagene Volcanism

Other leads in north-western Tasmania contain aquagene volcanics, but many sequences are deeply weathered and poorly exposed. Flow foot breccias were observed in the Expressway near Penguin and east of Upper Castra. Extensive pyroclastics, up to 200m thick, near West Ridgley, Cam River (Gee 1977) are partly tachylytic and may represent phreatic eruptions from the centre in a river section dammed by a basal flow.

DERWENT LEADS (Figures 6 & 7)

Basalts, with aquagene horizons, overlie Palaeocene-Oligocene sediments of the ancestral Derwent (Harris 1968) and are isotopically dated late Oligocene-early Miocene (21-30 m.y.; Sutherland *et al.* 1973 ; Sutherland 1976a). This survey describes aquagene volcanics at eighteen localities and the episodic damming is discussed in descending order downstream.

Nive Lead (Nive & Shannon 1:100 000 Sheets 8113 & 8213). Lavas erupted into the lead 14 km north west of Bronte Park from 900-600m elevation. Four flows of alkali, tholeiitic and transitional olivine basalts broaden west of Bronte, with a base at 560m elevation. They include 3-6m of pillowy lava and breccia under an olivine tholeiite at 650m on the Lyell Highway, east Nive crossing. Some diversion or damming of the Nive is indicated, possibly by downstream eruption from suspected dykes (Prider 1948) as basalts near Tarraleah contain glomeroporphyritic alkali basalt and orthopyroxene-olivine tholeiite, types not recognized at Bronte.

Flow foot breccias, over 10m thick, about 380m in elevation underlie massive olivine tholeiite on Long Spur (Grid ref. 8213-609050). This suggests flow into the Derwent-Nive junction dammed by earlier downstream lavas.

PLATE 9.- Massive lava overlying quench zone of flow foot breccias (weathered), Paloona Power Station Road, west of Hogg Creek.

Dee-Ouse Leads (Meander & Shannon 1:100 000 Sheets 8214 & 8213). Basalts fill the leads around Great Lake (Voisey 1949), Waddamana (Fairbridge 1949) and west of Ouse (Jennings 1955). The Waddamana section from 540-960m elevation includes olivine nephelinite, alkali olivine basalts, transitional olivine basalts, olivine tholeiites and tholeiite, with three horizons of flow foot breccias in Waddamana-Bashan Plains Road between 580-700m (Grid refs 8213-792325 to 801315). This suggests repeated damming until lavas overflowed divides into tributaries of the Ouse and Dee Leads.

Flows probably travelled considerable distances as petrographically related lavas occur around 920m elevation four and twelve km upstream and around 1000m elevation at Skittleball Plains seventeen km upstream of Waddamana. The Skittleball Plains tholeiite (23.6 m.y.) blocked the upper Ouse and may have ponded ancestral Great Lake, which received extensive phreatic tuffs and flow foot breccias from local emergent centres (Sutherland and Hale 1970; Sutherland *et al.* 1973; Sutherland 1973b). Older (65m thick) and younger (48m thick) aquagene successions with separate flow cappings suggest two pondings of Great Lake between 21.8 and 23.6 m.y., with later activity zeolitizing the earlier succession (Sutherland 1976b).

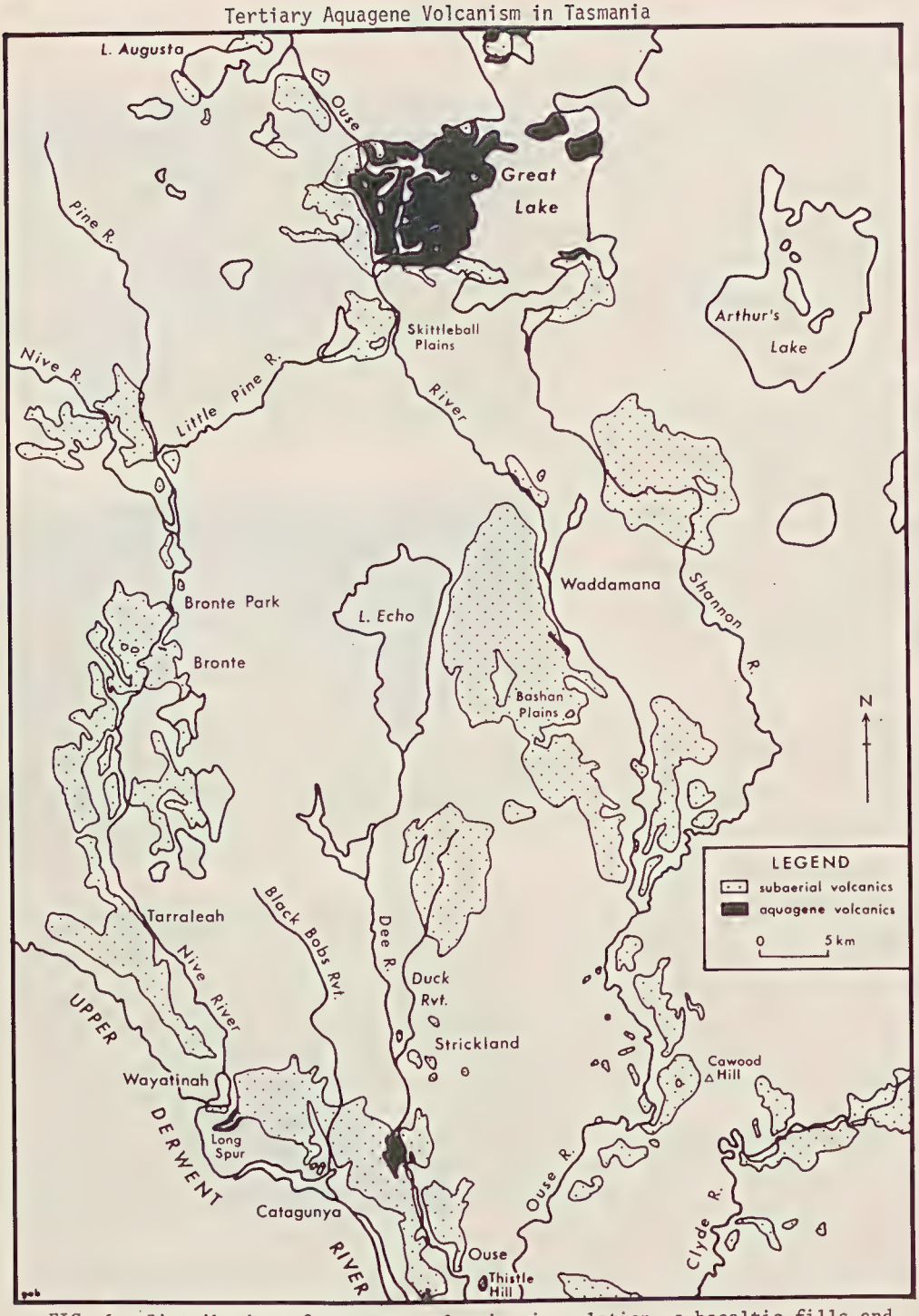


FIG. 6.- Distribution of aquagene volcanics in relation to basaltic fills and drainage, Upper Derwent and tributaries.

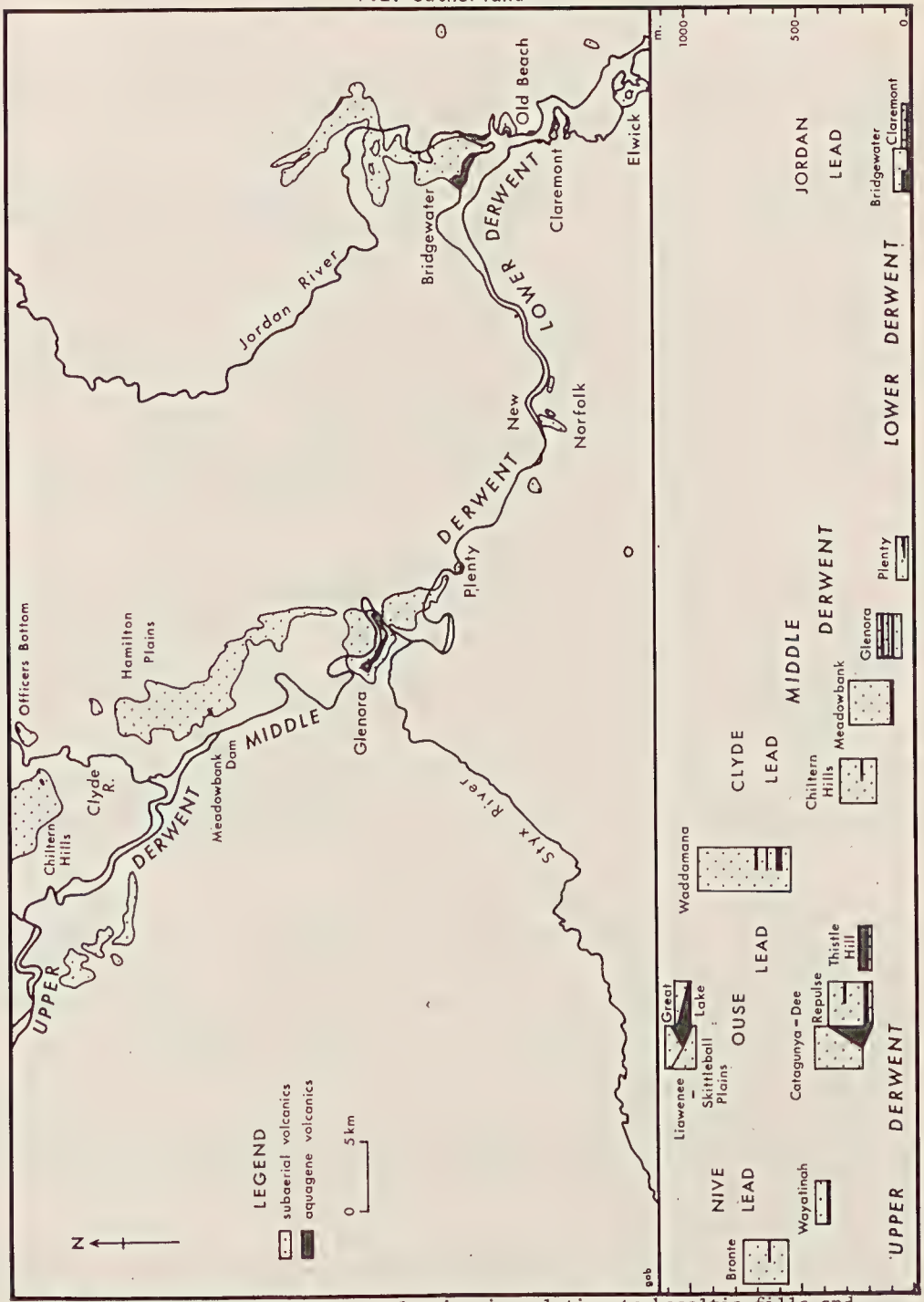


FIG. 7.- Distribution of aquagene volcanics in relation to basaltic fills and drainage, Middle-Lower Derwent and tributaries. Volcanic sections with aquagene volcanics, showing relative elevations and thicknesses, are shown below their projected geographic positions on the maps.

Repeated eruption down the lower Ouse and Dee Leads is represented by multiple flow remnants of up to twelve horizons in the Selma-Hartfield, Ousedale and Duck Creek - Strickland areas. Flow foot breccias appear in the Upper Derwent separated by lavas entering the lead below the Ouse and Dee junctions.

Upper Derwent Lead (Meander & Shannon 1:100 000 Sheets 8214 & 8213). The lowest flow foot breccias are olivine tholeiite capping massive alkali basalt around 200m elevation on Thistle Hill, 1.5 km south-west of Ouse. Two further horizons lie above Repulse Dam, 5.5 km west-south-west of Ouse. Tholeiitic breccias overlie massive olivine tholeiite above 200m elevation in a landslip and pass into massive tholeiite above 212m, and poorly exposed olivine tholeiite breccias appear around 312m elevation.

Extensive flow foot breccias in the Dee River banks along the highway 9 km north west of Ouse overlie massive basalt and sub-basaltic sediments above 200-320m elevation. The breccias dip easterly about 20° north-west of Dee crossing and are at least 45m thick, but possibly extend to 380m elevation for a maximum thickness of 180m. Massive capping flows, and draped interbasaltic sediments 3 km north-west of Dee crossing, outcrop up to 440m on Big Snake Hill. Breccias are not obvious west along Catagunya Road and massive flows fill the lead down to 220m elevation in Black Bobs Rivulet. The Dee-Catagunya basalts are all olivine tholeiites. Most probably entered down the Dee Lead, but dips in the breccias suggest some discharge into the Derwent from the Nive lead upstream.

Field and petrographic relationships tentatively suggest the following events —

a) Eruptions down Ouse or upstream leads repeatedly dammed the Derwent around Ouse and formed flow foot breccias at levels between 200-312 m elevation.
b) Eruptions down Dee Lead dammed the Derwent into a substantial lake between the Dee and Nive junctions.
c) Eruption down Nive Lead into the lake formed flow foot breccias to 380m elevation before overtopping.
d) Further eruptions down Dee Lead capped the Upper Derwent successions.

Clyde Lead (Shannon & Tyenna 1:100 000 Sheets 8213 & 8212). Basalts in Clyde Lead reach basal elevations of 370m east of Bothwell and include basanites, alkali basalts and olivine tholeiites. Sources are not obvious, but may include plugs at Shiners Hill, 12 km east-north-east of Bothwell, a vent-like breccia east of Sherwins Neck (Stephenson 1973) and overspilling from the Ouse Lead near Cawood Hill.

Minor flow foot breccias up to 3m thick are found in the flows in the lower Clyde east of Officers Bottom and around Chiltern Hills. They suggest limited local damming of the Clyde-Derwent junction by lavas descending these leads.

Middle Derwent Lead. Below Clyde junction, olivine tholeiites dominate Hamilton Plains - Meadowbank Dam sections. Basal flow foot breccias up to 10m thick on Meadowbank Dam road above 80m elevation, 0.5 km from the Dam, indicate downstream damming, possibly by lavas backing into the lead along Allendale Rivulet from a centre east of Glenora (Anandalwar 1960).

The Glenora centre incorporates at least seven flows of olivine tholeiite, with basal tuffs and breccias and pillow lava up to 15m thick, interbedded with fluvial and lacustrine sediments and fossil forests. The volcanic rocks overlie sediments of Lake Glenora and current bedded tachylytic tuffs and a pillowy horizon indicate episodic phreatic activity and quenching of lava.

Coarse tachylytic tuffs are interbedded with massive olivine tholeiites between 20-40m elevation above the Lyell Highway opposite Plenty. The overlying flows are interbedded with thin tuffaceous (?) sediment and on the north side overlie Tertiary

conglomerates, sands and clays in a lead cut in Triassic sandstones. The conglomerate contains cobbles of scoriaceous olivine tholeiite, but precise relationships to the tuffs and lower basalt are unexposed. The tachylytic tuffs resemble phreatic deposits, possibly erupted from a local centre into a dammed course of the Derwent.

Lower Derwent Lead (Derwent 1:100 000 Sheet 8312). Massive basanite enters the Lead at New Norfolk, overlying basaltic conglomerates and sands and olivine tholeiite (Sutherland 1976a). It reaches 40 m elevation and may be responsible for the level of damming and phreatic eruption at Plenty.

Flow foot breccias near the Jordan-Derwent junction at Bridgewater are disconformably overlain by massive olivine tholeiite of the Brighton Basalt (Sutherland 1977a). The breccias dip west-south-westerly (n.b. not easterly as inadvertently recorded in Sutherland) and probably erupted locally into the Derwent estuary standing 25-30m above present level.

Water-laid tachylytic tuffs, associated with flow foot breccias and olivine tholeiite flows between Old Beach and Claremont, suggest eruption into a higher Derwent course from a centre north-east of Claremont (n.b. as located in fig. 6, Sutherland 1976a, and not north-west as inadvertently recorded in that text).

Aquagene volcanics in the Lower Derwent indicate stands up to 30-40m above the present estuary, either due to downstream damming by lavas at Bridgewater, Claremont, Elwick and East Risdon or due to high Miocene sea-levels around Tasmania.

Derwent Aquagene Volcanism

Aquagene volcanics in Derwent sections (figure 7) mostly follow massive flows which dammed watercourses. Phreatic deposits erupted from emerging centres at Great Lake, Glenora, Claremont and possibly Plenty, but most flow foot breccias discharged into dammed confluences. Zeolitization was only pronounced adjacent to extended activity at Great Lake.

The flow foot breccias indicate lake levels up to 250m above the present Derwent drainage and maximum water depths up to 180m. Capping subaerial lavas reach thicknesses and heights up to 420m above present river levels, giving minimum erosion rates of 17-21m/m.y. for the last 20-25 m.y.

TASMANIAN SYNTHESIS

Tasmanian aquagene volcanism coincided with extensive Oligocene - Miocene outpourings and is concentrated in regions of Miocene marine transgression (north-western coast and off-shore islands) and major basaltic leads (Mersey-Forth and Derwent drainages). Further substantial finds are unlikely as most basaltic areas have been studied.

Coastal aquagene volcanism provides additional information on relative Miocene sea-levels. The inland aquagene volcanism provides information on repeated blocking and damming of the leads. The most continuous aquagene sections appear in coastal exposures, possibly due to eruption into widespread marine waters and good exposure in sea cliffs, but equivalent outcrop distances (up to 6 km) and thicknesses (over 80m) occur within inland leads.

Most aquagene volcanics are olivine tholeiites, with some examples of alkali or transitional olivine basalts and tholeiite. This probably reflects the most voluminous compositions erupted during wide spreading melting in the peak of volcanism and aquagene activity.

AUSTRALIAN COMPARISONS

The Tasmanian occurrences provide the best range of Cainozoic aquagene volcanism in Australia, compared with sporadic examples reported elsewhere in eastern Australia.

South East Australia

Vitric tuffs and tuffites drilled in Bass Strait are probably extensively developed in Miocene cones identified in marine seismic sections (Brown 1976). They represent submarine equivalents of north-western Tasmania coastal and island aquagene volcanoes.

In the Victorian Older Basalts, pillowy lava interbedded with early Miocene marine beds (Bowler 1963) is typical flow foot breccia formed by flow over the Miocene shore. Similar breccias in the Newer Volcanics on Lady Julia Percy Island (Stach and McIvor 1937) probably represent emergent eruption into Pleistocene seas. Maars, a feature of the Newer Volcanics in Western Victoria - South Australia, represent phreatic eruptions (Ollier and Joyce 1964) but such features are not preserved in the older Tasmanian province.

Aquagene volcanics are not well documented in New South Wales, but include flow foot breccias under a basalt plateau near Tuena, 0.5 km south of Abercrombie River, 1 km west of Noarla Homestead (P. Morrissey and author's observations).

North-eastern Australia

In the younger Queensland volcanics, maar-like tuff rings around Atherton (deKeyser *et al.* 1968) may result from activity in a high rainfall district (Stephenson *et al.* 1979).

Agglomerates and tuffs on Stevens Island, South Barnard Group (deKeyser and Lucas 1968) show features resembling phreatic and base surge deposits (R. Gunthorpe and author's observations). Similar palagonitic tuffs and agglomerates, with cross beds and scours, and some pillow lavas in volcanic islands in Torres Strait are related to phreatic and subaqueous activity as cones emerged from Pleistocene seas (Willmott *et al.* 1973).

Pillowed younger basalts have been noted in the Herbert and Wild River leads, west of Ingham-Innisfail region and minor flow foot breccia underlies Oligocene basalt on Recliffe Plateau. northern Bowen Basin (Stephenson *et al.* 1979).

South-West Pacific - Southern Ocean

Vitric tuffs and flow foot breccias below sheet lava in Norfolk and Phillip Island basalts, South West Pacific, are attributed to emergent eruption into Pliocene seas forming phreatic and quench features (Jones and McDougall 1973). They closely match structures in coastal island volcanoes of north-western Tasmania.

Cainozoic aquagene volcanism occurred on spreading sea-floors bounding the Tasmanian and Australian coasts (Veevers and McElhinny 1976). Pillows with intercalated oceanic ooze were drilled in Late Eocene basalt basement about 150 km west of Tasmania (DSDP Site 282; Kennett *et al.* 1975). Aquagene oceanic Miocene basalts exposed on Macquarie Island (Varne and Rubenach 1972) contrast with Tasmanian continental aquagene basalts in being metamorphosed to green schist facies and associated with amphibolite facies intrusives.

ACKNOWLEDGEMENTS

Considerable help was received from officers of the Hydro-Electricity Commission, Tasmania, in arranging hire of vehicles for much of the field work. Mr. G.E. Hale and

staff, Geology Section, H.E.C., provided copies of many geological maps and drilling records. Mr. R.H. Green, Queen Victoria Museum, Launceston, provided accommodation and assistance in the Mersey-Forth area and information on Black Pyramid Island. Mr. P. McGuire and family provided accommodation and assistance with travel on Hunter Island, where the author was accompanied by Mr. D.J. Jennings, Tasmanian Department of Mines. Miss S. Bowdler, Department of Prehistory, Australian National University, supplied material from Steep Island. Mr. M.E. Murrell accompanied the field trip to Robbins Island. Mr. B. Ritchie, Van Diemen's Land Co., gave permission for field work on the property at Flat Topped Bluff. Ms J. Hingley, the Australian Museum, assisted with field work in north-western Tasmania.

The project was initially sponsored by the Tasmanian Museum and Art Gallery, under the Director, Mr. D. Gregg, prior to its continuation on the author's employment at the Australian Museum. Dr. P.G. Quilty, School of Earth Sciences, Macquarie University, kindly examined material for fossils from Flat Topped Bluff. Dr. M.R. Banks, Geology Department, University of Tasmania commented on the script.

REFERENCES

Anandalwar, M.A., 1960: Geology and structure of the Middle Derwent Valley. *Pap. Proc. R. Soc. Tasm.*, 94: 13-24.

Banks, M.R., 1955: Tertiary fossil forest at Macquarie Plains. *Tasmanian Naturalist*, II(3): 1-11.

_____, 1962a: Volcanism *in* Cainozoic. In Spry, A. and Banks, M.R. (Eds): GEOLOGY OF TASMANIA. *J. geol. Soc. Aust.*, 9: 233-253.

_____, 1962b: Marine Succession. In Cainozoic, *ibid.*

Bowler, J.M., 1963: Tertiary stratigraphy and sedimentation in the Geelong-Maude area, Victoria. *Proc. R. Soc. Vict.*, 76: 69-137.

Brown, B.R., 1976: Bass Basin - Some aspects of the petroleum geology. In Leslie, R.B., Evans, H.J. and Knight, C.L. (Eds): ECONOMIC GEOLOGY OF AUSTRALIA AND PAPUA NEW GUINEA - 3. PETROLEUM. Aust. Inst. Min. Metall., Parkville, Victoria, 67-82.

Burns, K.L., 1964: One mile Geological map series K/55-6-29, Devonport. *Explan. Rep. geol. Surv. Tasm.*

Colhoun, E.A., 1978: Recent Quaternary and geomorphological studies in Tasmania. *Austr. Quat. Newsletter*, 9: 5-13.

Fairbridge, R.W., 1949: The geology of the country around Waddamana, Central Tasmania. *Pap. Proc. R. Soc. Tasm.* (1948): 111-151.

Ford, R.J., 1960: The geology of the Fisher River area. *Pap. Proc. R. Soc. Tasm.*, 94: 25-32.

Gee, R.D., 1977: Geological Atlas 1 mile series. Zone 7 Sheet 28 (8015N). Burnie. *Explan. Rep. geol. Surv. Tasm.*

Green, R.H. and Macdonald, D., 1963: The Black Pyramid gannetry. *The Emu*, 63(3): 177-184.

Harris, W.K., 1968: Tasmanian Tertiary and Quaternary microfloras. Summary Report. *Palaeont. Rep. geol. Surv. S.Aust.* 5/68.

Jennings, I.B., 1955: Geology of portion of the Middle Derwent area. *Pap. Proc. R. Soc. Tasm.*, 89: 169-190.

_____, 1963: One mile Geological map series K55-6-45, Middlesex. *Explan. Rep. geol. Surv. Tasm.*

Jennings, J.N., 1959: The coastal geomorphology of King Island, Bass Strait, in relation to changes in the relative level of land and sea. *Rec. Q. Vict. Mus.*, N.S. 11, 39 pp.

Jones, J.G. and McDougall, I., 1973: Geological history of Norfolk and Philip Islands, South West Pacific Ocean. *J. geol. Soc. Aust.*, 20: 239-257.

Kennett, J.P., Houtz, R.E., *et al.*, 1975: Initial Reports of the Deep Sea Drilling Project. XXIX, Washington (U.S. Government Printing Office). 9. Site 282: 317-363.

Kershaw, R.C. and Sutherland, F.L., 1972: Quaternary geomorphology of Flinders Island. *Rec. Q. Vict. Mus.*, 43.

Keyser, F. de, and Lucas, K.G., 1968: Geology of the Hodgkinson and Laura Basins, north Queensland. *Bull. Bur. Miner. Resour. Geol. Geophys. Aust.*, 84.

Ollier, C.D. and Joyce, E.B., 1964: Volcanic physiography of the western plains of Victoria. *Proc. R. Soc. Vict.*, 77: 357-376.

Paterson, S.J., 1967: Tertiary deep lead deposits in the Moina area. *Pap. Proc. R. Soc. Tasm.*, 101: 251-260.

Prider, R.T., 1948: Geology of the country around Tarraleah, Tasmania. *Pap. Proc. R. Soc. Tasm.* (1947): 127-150.

Quilty, P.G., 1972: The biostratigraphy of the Tasmanian Marine Tertiary. *Pap. Proc. R. Soc. Tasm.*, 106: 25-44.

_____, 1977: Cenozoic sedimentation cycles in Western Australia. *Geology*, 5: 336-340.

Rawlings, G.E., 1967: Sub-basaltic sediments and metasediments of the Mersey-Forth area. *Pap. Proc. R. Soc. Tasm.*, 101: 267-270.

Spry, A.H., 1958: Precambrian rocks of Tasmania, part III. Mersey-Forth area. *Pap. Proc. R. Soc. Tasm.*, 92: 117-137.

Stach, L.W. and McIvor, E., 1937: Lady Julia Percy Island - general geology: petrology. McCoy Society. *Proc. R. Soc. Vict.*, 49(2): 336-348.

Stephenson, P.C., 1973: Geological examination of No. 5 dam site on the Clyde River. *Tech. Rep. Dep. Mines Tasm.*, 16: 195-198.

Stephenson, P.J., Griffin, T.J. and Sutherland, F.L., 1979 in prep: Cainozoic volcanism in Northeastern Australia. In Henderson, R.A. and Stephenson, P.J. (Eds.) GEOLOGY & GEOPHYSICS OF NORTH EASTERN AUSTRALIA. *Geol. Soc. Aust. Qd Div.*, James Cook Univ. Press, Townsville.

Sutherland, F.L., 1965: Some new occurrences of zeolites and associated minerals in the Tertiary basalts of Tasmania. *Aust. J. Sci.*, 28: 26.

_____, 1969: A review of the Tasmanian Cainozoic volcanic province. *Spec. Publs geol. Soc. Aust.*, 2: 133-144.

_____, 1971: The geology and petrology of the Tertiary volcanic rocks of the Tamar Trough, northern Tasmania. *Rec. Q. Vict. Mus.*, 36.

_____, 1973a: The geological development of the southern shores and islands of Bass Strait. *Proc. R. Soc. Vict.*, 85(2): 133-144.

_____, 1973b: Igneous rocks, Central Plateau. In Banks, M.R. (Ed.): THE LAKE COUNTRY OF TASMANIA. *R. Soc. Tasm.*, Hobart: 43-54.

_____, 1976a: Cainozoic volcanic rocks. In Leaman, D.E., Geological Atlas 1:50 000 series. Sheet 82 (8312S). Hobart. *Explan. Rep. geol. Surv. Tasm.* 35-56 and Appendix 5, 111.

_____, 1976b: Tacharanite from Tasmania. *Min. Mag.*, 40: 887-890.

_____, 1977a: Cainozoic volcanic rocks. In Leaman, D.E., Geological Atlas 1:50 000 series. Sheet 75 (8312N). Brighton. *Explan. Rept. geol. surv. Tasm.* 25-37.

_____, 1977b: Zeolite minerals in the Jurassic dolerites of Tasmania: their use as possible indicators of burial depth. *J. geol. Soc. Aust.*, 24: 171-178.

_____ and Corbett, K.D., 1967: The Tertiary volcanic rocks of far north-western Tasmania. *Pap. Proc. R. Soc. Tasm.*, 101: 71-90.

_____ and Hale, G.E.A., 1970: Cainozoic volcanism in and around Great Lake, Central Tasmania. *Pap. Proc. R. Soc. Tasm.*, 104: 17-32.

_____, Green, D.C. and Wyatt, B.W., 1973: Age of the Great Lake basalts, Tasmania, in relation to Australian Cainozoic volcanism. *J. geol. Soc. Aust.*, 20: 85-93.

Varne, R. and Rubenach, M.J., 1972: Geology of Macquarie Island and its relationship to oceanic crust. In Hayes, D.E. (Ed.): ANTARCTIC OCEANOLOGY II: THE AUSTRALIAN-NEW ZEALAND SECTOR, ANTARCTIC RES. SERIES, 19: 251-266. *Amer. Geophys. Union*, Washington, D.C.

Veevers, J.J. and McElhinny, M.W., 1976: The separation of Australia from other continents. *Earth-Sci. Rev.*, 12: 139-159.

Voisey, A.H., 1949: The geology of the country around Great Lake, Tasmania. *Pap. Proc. R. Soc. Tasm.* (1948): 95-104.

Willmott, W.F., Whitaker, W.G., Palfreyman, W.D., and Trail, D.S., 1973: Igneous and metamorphic rocks of Cape York Peninsula and Torres Strait. *Bull. Bur. Miner. Resour. Geol. Geophys. Aust.*, 135.

Papers and Proceedings of the Royal Society of Tasmania, Volume 114, 1980.

(ms. received 23.8.1979)

LITHOSTRATIGRAPHY AND BIOSTRATIGRAPHY OF THE FLORENTINE VALLEY FORMATION IN THE TIM SHEA AREA, SOUTHWEST TASMANIA

by Bryan Stait and John Laurie
Department of Geology, University of Tasmania

(with three text figures)

ABSTRACT

STAIT, B. and LAURIE, J., 1980 (31 v): Lithostratigraphy and biostratigraphy of the Florentine Valley Formation in the Tim Shea area, southwest Tasmania. *Pap. Proc. R. Soc. Tasm.*, 114: 201-207. ISSN 0080-4703. Department of Geology, University of Tasmania, Australia.

The Florentine Valley Formation is defined. The Formation is subdivided into three members; the Churchill Sandstone Member, the Pontoon Hill Siltstone Member, and the Mt. Field Siltstone Member. Seven consecutive fossil assemblages based on brachiopods and trilobites can be recognised within the Florentine Valley Formation. International correlation of the assemblages in the Florentine Valley Formation is based on graptolites, that of the basal Karmberg Limestone on graptolites and conodonts. The Formation ranges in age from Early Tremadoc to Late Arenig.

INTRODUCTION

The Florentine Valley lies approximately 100 km west of Hobart. Access to the Valley is provided by the Gordon Road and by private logging roads owned and maintained by Australian Newsprint Mills (see fig. 1).

The Florentine Valley Formation outcrops on the eastern and southern sides of the Florentine Valley, along the eastern limb of the Florentine Synclinorium. The Florentine Valley Formation is best exposed in the southern end of the Valley along the Gordon Road, directly west of the Needles and along the Florentine Road at the Gap. A more detailed discussion of the geological setting can be found in Corbett and Banks (1974).

Lewis (1940) described within his Junee Series from the Tim Shea-Maydena area a fine-grained clastic sequence from which Kobayashi (1940) described a brachiopod, gastropod and trilobites. He assigned an Early Ordovician age to this fauna. The only previous description of the fauna from these beds was that of Etheridge (1904). Later Brown (1948) described a small brachiopod fauna from near Maydena and the Gap. To this she assigned an Early Ordovician age. Thomas (1960) and Quilty (1971) have illustrated graptolites from the Florentine Valley Formation. Faunal lists can also be found in Öpik (1951), Banks (1962) and Corbett (1963). Corbett and Banks (1974) described the lithostratigraphy of the Florentine Valley Formation in three sections (but did not establish formal members) and also established a preliminary biostratigraphy.

LITHOSTRATIGRAPHY

Banks (1962) formally raised the Florentine Valley Mudstone to the formational level. Corbett and Banks (1974) changed the name to the Florentine Valley Formation and defined it as "that formation of sandstone and siltstone with lesser limestone and chert which conformably overlies the Tim Shea Sandstone and Reeds Conglomerate and underlies the Gordon Limestone Sub-Group" (fig. 2). No type section was named and no boundaries were defined. Because no complete section of the Florentine Valley Formation exists it is necessary to define the base and the top of the Formation in different sections. Along the Gordon Road the top is faulted away and along the Florentine Road

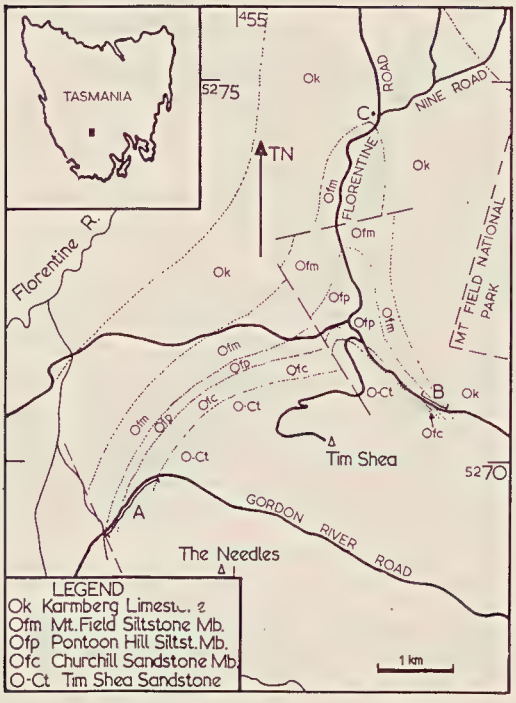


FIG. 1.- Map showing location of collected sections within the Florentine Valley.

the base does not outcrop.

The base of the formation is herein defined as occurring in a creek crossing the Gordon Road approximately 18 km from Maydena, just west of the Humboldt Divide, (State Grid. ref. Wedge 8112: 539698). This locality is on the western limb of the Tim Shea Anticline (see fig. 1). The base is chosen as the boundary between the coarse reddish sandstone typical of the Tim Shea Sandstone and the fine grey bioturbated sandstone above. The boundary is transitional. The top of the formation is defined as the base of the lowest lenticular body of limestone occurring in the cutting on the Florentine Road 150 metres east of the highest point on the road at the Gap (State Grid. ref. Wedge 8112:581707). The overlying formation is the Karmberg Limestone. This locality is on the eastern limb of the Tim Shea Anticline.

Corbett and Banks (1974) did not establish formal members, but following recent work by the authors it is now considered feasible to subdivide the Florentine Valley Formation into three members, as follows (fig. 3).

Churchill Sandstone Member (nov. (Nov.):- This is the basal member of the Florentine Valley Formation and occurs along the Gordon Road (State Grid. ref. Wedge 8112: Base 539698, top 535694). It consists of thickly-bedded, bioturbated grey sandstone containing rare gastropods, and is 75 m thick along the Gordon Road.

Pontoon Hill Siltstone Member (nov.):- This is the middle member of the Florentine Valley Formation, and is best exposed on the Gordon Road near the 12 mile post (19 km from Maydena), (State Grid. ref. Wedge 8112: Base 535694, top 529685). It consists of a basal white siltstone overlain by interbedded yellow siltstone and nodular siltstone, overlain in turn by dark grey calcareous siltstone and with interbedded yellow siltstone and nodular siltstone at the top. This member is 260 m thick along the Gordon Road and contains a diverse fauna of trilobites, brachiopods, gastropods, graptolites and ostracods.

Mt. Field Siltstone Member (nov.):- This is the uppermost member of the Florentine Valley Formation and is best exposed at the Gap. It consists of interbedded calcsiltstone, siliceous siltstone and fine siliceous sandstone overlain by finely bedded siltstone and is 55 m thick. It contains a diverse fauna of brachiopods, trilobites, gastropods, and graptolites. Underlying this member at the Gap are interbedded yellow siltstone and nodular siltstone of the Pontoon Hill Siltstone Member.

Corbett (1975) in describing the Upper Cambrian and Lower Ordovician sequences from the Denison Range, established the Denison Sub-Group, of which the uppermost formation is the Squirrel Creek Formation (fig. 2). Corbett (1975) divided the Squirrel

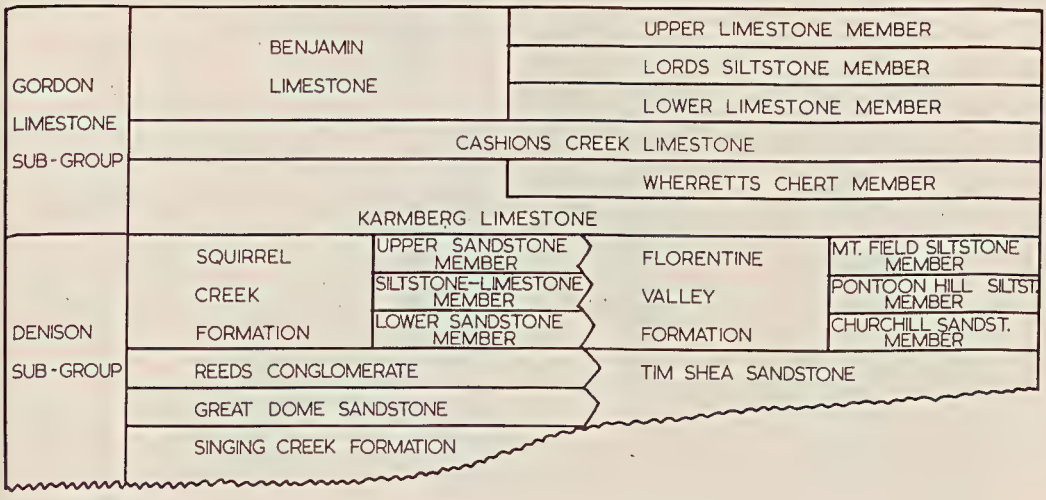


FIG. 2.- Denison Sub-Group and Gordon Limestone Sub-Group Stratigraphy (modified from Corbett and Banks 1974).

Creek Formation into three members: a Lower Sandstone Member overlain by a Siltstone-Limestone Member, of interbedded grey to yellow calcareous siltstone, fine sandstone and impure nodular limestone, and an Upper Sandstone Member. The two lower members are quite similar lithologically to the lower two members of the Florentine Valley Formation. The Upper Sandstone Member consists of grey-green and buff coloured quartoze and micaceous sandstone with inter-bedded siltstone with glauconite bands, and differs from the Mt. Field Siltstone Member of the Florentine Valley Formation in the predominance of sandstone, the presence of glauconite and in its much greater thickness.

From collections of fossils made by Corbett from the lower two members of the Squirrel Creek Formation it would appear that they are biostratigraphically equivalent to those of the Florentine Valley Formation.

BIOSTRATIGRAPHY

Recent work by the authors on the trilobites (Stait) and brachiopods (Laurie, in press), has made possible an initial biostratigraphic subdivision of the Florentine Valley Formation. Formal zones are not erected because of a reliance on only two sections which, to a large extent, do not overlap.

Within the formation can be recognised seven assemblages based on the ranges of

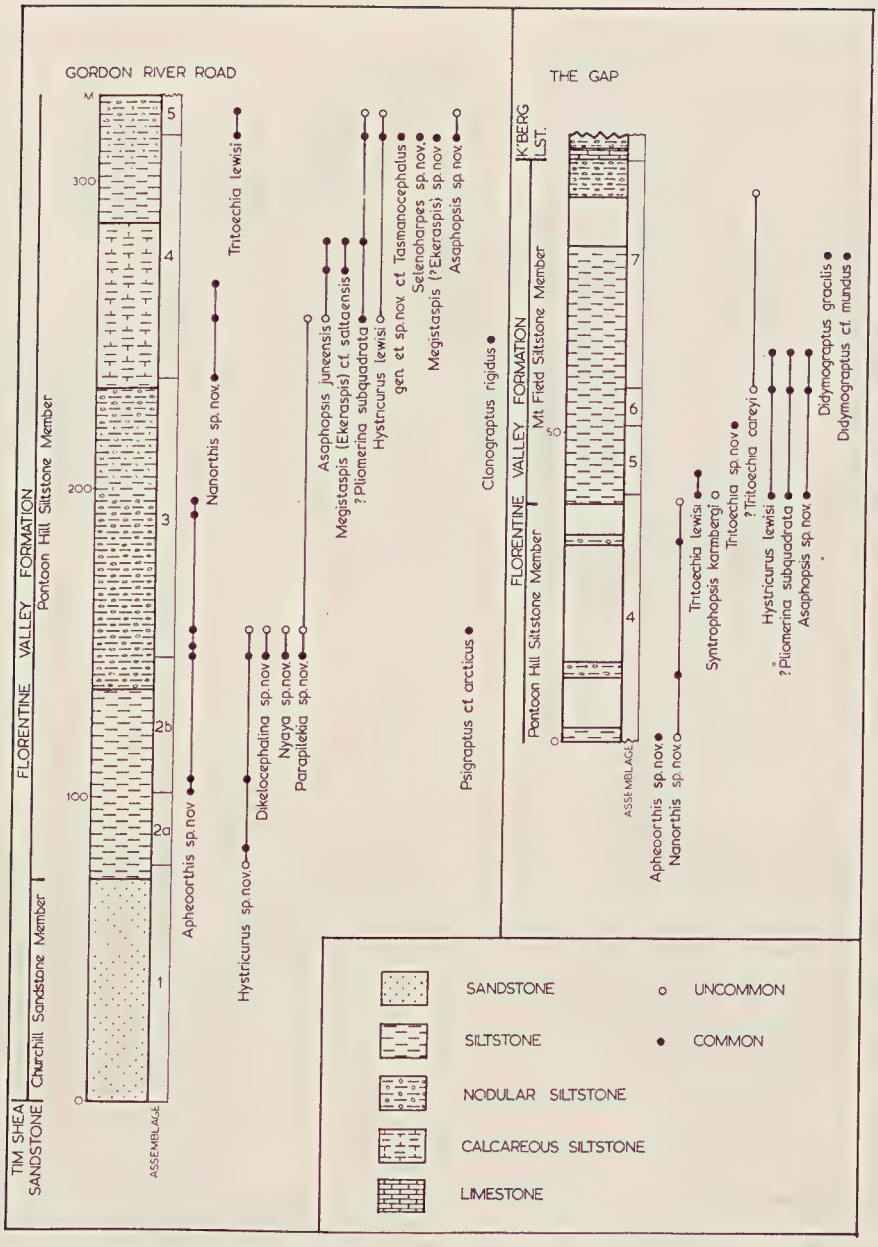


FIG. 3.- Stratigraphic sections of the Florentine Valley Formation showing the lithological units and the ranges of the faunal elements.

trilobites and brachiopod species (fig. 3). The two sections used to establish these assemblages are correlatable via assemblage 5 which occurs in both.

The assemblages are as follows:

Assemblage 1 :- *Lesueurilla* (identification, Dr. E. Yochelson pers. comm.)

Assemblage 2 :- *Hystricurus* sp. nov., *Westonia* sp., *Apheoorthis* sp. nov.

2a:- *Hystricurus* sp. nov., *Westonia* sp.

2b:- *Hystricurus* sp. nov., *Westonia* sp., *Apheoorthis* sp. nov.

Assemblage 3 :- *Hystricurus* sp. nov., *Parapilekia* sp. nov., *Dikelocephalina* sp. nov., *Nyaya* sp. nov., *Apheoorthis* sp. nov., *Psigraptus* cf. *arcticus* Jackson (identification, Dr. R.B. Rickards pers. comm.)

Assemblage 4 :- *Parapilekia* sp. nov., *?Pliomerina subquadrata* (Kobayashi), *Megistaspis (Ekeraspis)* cf. *saltaensis* (Kayser), *Asaphopsis juneensis* Kobayashi, *Hystricurus lewisi* (Kobayashi), *Nanorthis* sp. nov., *Clonograptus rigidus* (Hall).

Assemblage 5 :- *?Pliomerina subquadrata* (Kobayashi), *Megistaspis (Ekeraspis?)* sp. nov., *Selenoharpes* sp. nov., *Asaphopsis* sp. nov., gen. et sp. nov. (aff. *Tasmanocephalus*), *Hystricurus lewisi* (Kobayashi), *Tritoechia lewisi* Brown, *Syntrophopsis karmbergi* Brown.

Assemblage 6 :- *?Pliomerina subquadrata* (Kobayashi), *Hystricurus lewisi* (Kobayashi), *Asaphopsis* sp. nov., *Tritoechia* sp. nov. 1.

Assemblage 7 :- *?Pliomerina subquadrata* (Kobayashi), *Hystricurus lewisi* (Kobayashi), *Asaphopsis* sp. nov., *Tritoechia careyi* Brown, *Didymograptus gracilis*, *D.* cf. *mundus*, *Clonograptus* sp., *Tetragraptus* sp.

The UTGD catalogue members of the new species and genera can be found in Appendix 1, while the new classifications of specimens figured in Corbett and Banks can be found in Appendix 2.

The top of assemblage 7 fortunately coincides with the top of the Florentine Valley Formation. A diverse conodont fauna is found at the base of the Karmberg Limestone (Burrett and Stait, in prep.). Approximately five metres above this is a fauna containing *Leptella* sp. nov. This fauna correlates with the base of the Karmberg Limestone at Nine Road-Florentine Road junction (C. of fig. 1) which contains *Geragnostus* sp., *?Dimeropygiella* sp., aff. *Carolinites* sp., *Selenoharpes* sp., *Tasmanocephalus stephensi*, *Archaeorthis* sp. nov., *Tritoechia* sp. nov. 2, *Leptella* sp. nov.

Correlation of the Florentine Valley Formation is obtained from examination of assemblage 3 and upper assemblage 7 - lower Karmberg Limestone faunas. Assemblage 3 contains *Apheoorthis* and *Nyaya* which on the Siberian Platform occur in the Nyaika horizon (Sokolov and Tesakov, 1975). Rozova (1968) placed the Nyaika horizon at the base of the Ordovician, while Yadrenkina (1974) had the Khantaika horizon as the basal horizon with the Nyaika horizon above it. Assemblage 3 also contains *Psigraptus* cf. *arcticus* which occurs in Assemblage 3 of Cooper (1979) to which he assigned an age of Lancefieldian 1.5 (Early Tremadoc). The Florentine Valley Formation is approximately 100 m thick below this assemblage and the base may thus be Late Cambrian, although there is no faunal evidence to support this. Assemblage 4 contains *Clonograptus rigidus* which Cooper (1979) included in his Assemblage 4, to which he assigned a Lancefieldian 2 age (Late Tremadoc).

The upper part of assemblage 7 - lower Karmberg Limestone contains the graptolites *Didymograptus gracilis* (assemblage 7) and *Phyllograptus anna* and *P. ilicifolius* (lower Karmberg Limestone). The Karmberg Limestone graptolites indicate a correlation with the Upper *Didymograptus extensus* zone in the Skiddaw Group (Jackson, 1962), suggesting a Castlemanian age (Strachan 1972).

The conodonts from the base of the Karmberg Limestone are correlatable with the

Upper *Prioniodus (Oepikodus) evae* Zone (Dr. C. Burrett pers. comm.), which Lindström (1971) regarded as very Late Early Arenig (*Didymograptus nitidus* Zone).

ACKNOWLEDGEMENTS

The authors wish to thank Drs. M.R. Banks, C.F. Burrett and K.D. Corbett for critically reading the manuscript, and to the H.E.C. and Australian Newsprint Mills for allowing unlimited access to areas under their control.

REFERENCES .

Banks, M.R., 1962: The Ordovician System *In* Spry, A.H. and Banks M.R. (eds): THE GEOLOGY OF TASMANIA. *J. geol. Soc. Aust.*, 9(2): 147-176.

Brown, I.A., 1948: Lower Ordovician brachiopods from the Junee district, Tasmania. *J. Paleont.* 22: 35-39, pl. 9.

Corbett, K.D., 1963: Geology of the Florentine Valley area. *B.Sc. Hon. Thesis (unpubl.)*, University of Tasmania.

_____, 1975: The Late Cambrian to Early Ordovician sequence on the Denison Range, southwest Tasmania. *Pap. Proc. R. Soc. Tasm.*, 109: 111-120.

_____, and Banks, M.R., 1974: Ordovician stratigraphy of the Florentine Synclinorium, southwest Tasmania. *Pap. Proc. R. Soc. Tasm.*, 107: 207-238.

Cooper, R.A., 1979: Sequence and correlation of Tremadoc graptolite assemblages. *Alcheringa*, 3(1): 7-19.

Etheridge, R., 1904: Trilobite remains collected in the Florentine Valley, western Tasmania, by Mr. T. Stephens, M.A., *Rec. Aust. Mus.*, 5: 89-101.

Jackson, D.E., 1962: Graptolite zones in the Skiddaw Group in Cumberland, England. *J. Paleont.*, 36(2): 300-313.

Kobayashi, T., 1940: Lower Ordovician fossils from Junee, Tasmania. *Pap. Proc. R. Soc. Tasm.*, (1939): 61-66.

Laurie, J.R., (in press). Early Ordovician Orthide brachiopods from southern Tasmania. *Alcheringa.*

Lewis, A.N., 1940: Geology of the Tyenna Valley. *Pap. Proc. R. Soc. Tasm.* (1939): 33-59.

Lindström, M., 1971: Lower Ordovician conodonts of Europe. *In* Sweet, W.C. and Bergstrom, S.M. (eds): SYMPOSIUM ON CONODONT BIOSTRATIGRAPHY. *Mem. geol. Soc. Amer.*, 127: 21-61.

Öpik, A.A., 1951: Notes on the stratigraphy and palaeontology of Cambrian, Ordovician and Silurian rocks in Tasmania. *Bur. Min. Resour. Austr. Rec.*, 1951-55.

Quilty, P.G. 1971: Cambrian and Ordovician dendroids and hydroids of Tasmania. *J. geol. Soc. Aust.* 17: 171-189.

Rozova, A.V., 1968: Biostratigraphy and trilobites of the Upper Cambrian and Lower Ordovician of North-West Siberian Platform. *Acad. Sci. U.S.S.R. Sib. Div., Inst. Geol. Geophys.*, 36: 3-196.

Sokolov, B.S. and Tesakov, Yu. I., (eds) 1975: ORDOVICIAN STRATIGRAPHY OF THE SIBERIAN PLATFORM. Pub. House. "NAUKA" Siberian Branch, 5-251.

Strachan, I., 1972: Correlation of British and Australian Graptolite Zines. *In:* Williams, A. *et al.* (ed.) A CORRELATION OF ORDOVICIAN ROCKS IN THE BRITISH ISLES. *Geol. Soc. Lond. Spec. Rept.*, 3: 10-14.

Thomas, D.E., 1960: The zonal distribution of Australian graptolites. *J. R. Soc. N.S.W.*, 94: 1-58.

Yadrenkina, A.G., 1974: Upper Cambrian and Ordovician brachiopods of the North-western Siberian Platform. *S.N.I.I.G.I.M.S.*, 151: 1-163.

APPENDIX 1

University of Tasmania Geology Department catalogue numbers for the specimens of the genera and species mentioned in the text. This list is to enable checks on the assignments to be made before the taxonomic work appears.

Trilobites

Hystricurus sp. nov., U.T.G.D. 95972-76.
Parapilekia sp. nov., U.T.G.D. 95987-89.
Dikelocephalina sp. nov., U.T.G.D. 95977-82.
Nyaya sp. nov., U.T.G.D. 95983-86.
?Pliomerina subquadrata, U.T.G.D. 95992, 96000-05, 96028-29.
Megistaspis (Ekeraspis) cf. *saltaensis*, U.T.G.D. 95993-95.
Asaphopsis juneensis, U.T.G.D. 95991.
Megistaspis (Ekeraspis?) sp. nov., U.T.G.D. 96002-05, 96014-15.
Selenoharpes sp. nov., U.T.G.D. 96007-10.
Asaphopsis sp. nov., U.T.G.D. 96034-38, 96054.
gen. et sp. nov. (cf. *Tasmanocephalus*), U.T.G.D. 95999, 96021-27.
Hystricurus lewisi, U.T.G.D. 96039-44, 96052, 96073.

Brachiopods

Apheoorthis sp. nov., U.T.G.D. 97335-47.
Nanorthis sp. nov., U.T.G.D. 93748-63.
Tritoechia lewisi, U.T.G.D. 97366, 68, 71, 74-76, 80, 82, 84, 85.
Tritoechia sp. nov. 1, U.T.G.D. 97397-413.
Tritoechia sp. nov. 2, U.T.G.D. 97427-42.

APPENDIX 2

The assignments given to material figured in Corbett and Banks (1974) in the present study.

Trilobites

"Asaphopsis" juneensis - *Asaphopsis* sp. nov.
Hystricurus paragenulatus - *Hystricurus lewisi*.
Hystricurus sp. - *Hystricurus lewisi*.
"Asaphellus" lewisi - *Megistaspis (Ekeraspis?)* sp. nov.
Hystricurus cf. *paragenulatus* - *Hystricurus lewisi*
Cybelopsis sp. - *?Pliomerina subquadrata*

Brachiopods

Finkelnburgia cf. *bellatula* - *Apheoorthis* sp. nov.
Apheoorthis sp. - *Apheoorthis* sp. nov.
?Nanorthis - *Nanorthis* sp. nov.
Nanorthis cf. *hamburgensis* - *Nanorthis* sp. nov.
Nanorthis sp. - *Nanorthis* sp. nov.
Apheoorthis cf. *meeki* - *Apheoorthis* sp. nov.
Apheoorthis cf. *emmonsi* - *Apheoorthis* sp. nov.
?Tritoechia careyi - *Tritoechia* sp. indet.

Papers and Proceedings of the Royal Society of Tasmania, Volume 114, 1980.

(ms. received 19.7.1979)

A SURVEY OF BIRDS OF THE LOWER GORDON REGION SOUTHWESTERN TASMANIA

by R.W. Rose
Zoology Department, University of Tasmania

(with one table and one text figure)

ABSTRACT

ROSE, R.W., 1980 (31 v): A survey of the birds of the Lower Gordon region, southwestern Tasmania. *Pap. Proc. R. Soc. Tasm.*, 114, 209-218. ISSN 0080-4703. Department of Zoology, University of Tasmania, Hobart, Tasmania, Australia.

An area of southwestern Tasmania, the lower Gordon River, was surveyed for bird species during the summers of 1975/76, 1976/77 and 1977/78. Using a transect method of survey, 49 species were located; of these, six were considered very common, 12 common, 24 uncommon and seven rare.

No new species were discovered, but the known range of all species recorded was extended by the survey. The rare orange-bellied parrot was not located during the study.

Bird species were correlated with vegetation structure based on the Specht classification. This classification, in retrospect, proved to be of only limited use but still showed broad habitat preference trends.

The area surveyed appears to be typical of southwestern Tasmania but is unusual, if not unique, in that not one species of exotic bird was discovered in the study area, suggesting that the area is true wilderness.

INTRODUCTION

Southwestern Tasmania is a large, relatively inaccessible area with a mountainous terrain and high rainfall. Because of this, few detailed ornithological studies have been carried out. The area as a whole is unique in an Australian context because of the large area of temperate rainforest and hummock sedgeland.

The part of southwestern Tasmania reported upon in this paper is an area not previously visited by ornithologists; hence its avifauna is unknown. Bird lists for some adjacent areas are available and the data from Thomas and Wall (1972) and Thomas (1979) are particularly relevant. With the exception of hardy bushwalkers, the area has been visited only by loggers (principally after huon pine) and officers of the Hydro-Electric Commission of Tasmania (H.E.C.) in an attempt to assess the hydro-electric potential of the area. This report is one of a series of studies commissioned by the H.E.C.

A map of the study area is shown in figure 1. The area surveyed extended from near Butlers Island and the Franklin River in the north to the Olga and Hardwood valleys in the south. Tributaries of the Gordon River that were surveyed included the Denison, Orange, Sprent, Olga and Maxwell Rivers.

The vegetation of the region has been described by Jarman and Crowden (1978).

The climatic climax of the area is temperate rainforest (closed forest). However a combination of factors such as soil fertility, drainage, fire frequency and selective logging have acted to modify the vegetation (Jackson, 1965). Hence the overall pattern

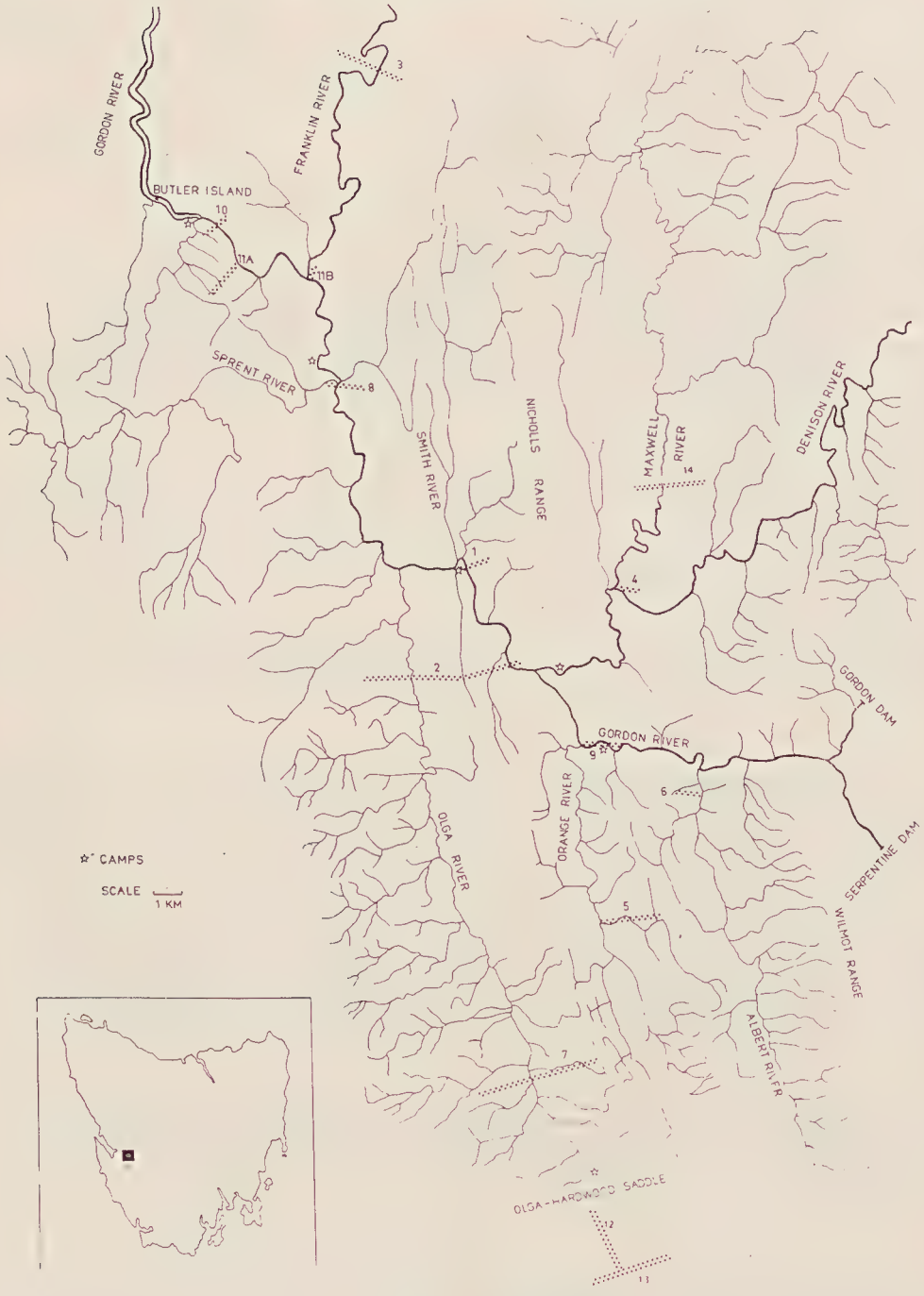


FIG. 1.- Locality Map

of the area is one of a mosaic of community types composed of temperate rainforest, wet sclerophyll, scrub, heathland, sedgeland and bog communities (Jarman and Crowden 1978).

The major objective of this study was to determine the avifauna of regions which may be considered for hydro-electric development. Other objectives included the determination of the status of each bird species (common, rare etc.) and associations of bird species with the vegetation.

Rose (1978a) has shown that although southwestern Tasmania as a whole has many more species than believed by Ridpath and Moreau (1966) its avifauna should still be regarded as depauperate. This study reinforces that view.

METHODS

The study area was surveyed by a simple transect method. Fourteen transects (see figure 1) were cleared prior to the survey. The transects were approximately 1 metre wide and varied in length from 250 m to 7-8 km. Transect slope varied from flat to extremely steep. Transects were marked by a red tape every 50 m so that it was possible to pinpoint the locality of each bird for future correlations.

The identity and number of bird species for each 50 m of a transect were noted but not the number of individuals of each species and so determinations of abundance could only be crude estimates.

The survey was carried out from very late spring to late summer 1975-76, 1976-77 and 1977-78. Seven visits, each of approximately one week duration, were made. At least two observers were in the field at any one time but this was increased to four or five on several occasions. Altogether approximately 600 man hours of observations were made.

At the completion of a day's observation, records were transferred to data sheets which listed all bird species and their position on the transect lines. This allowed later analysis for the following:
(a) Species list for each transect.
(b) Correlation of bird species with vegetation.
(c) Relative abundance of each species.

Vegetation structure was used as a basis for habitat/bird species correlation. The habitats, which were classified according to Specht (1970), were simplified by the lumping of certain habitats. For example closed forest comprised tall closed forest, and low closed forest; scrub was lumped with shrubs while heath and sedgeland were treated as a single habitat.

RESULTS

The results are presented in table 1 listing all bird species located on the transects. Scientific species names are given in Appendix A. Further details of results may be obtained from Rose (1978b).

Table 1 illustrates the correlation of bird species with the simplified vegetation structure and details the number of different species in each habitat. Perhaps surprisingly, closed forest, open forest, woodland and heath/sedgeland have similar numbers of bird species although the composition of the avifauna in each habitat differs somewhat. Scrub shows the highest number of species, having birds characteristic of both forest and open habitats as well as several birds found only in scrub, illustrating the importance of edge effects.

TABLE 1

BIRD SPECIES, RELATIVE ABUNDANCE AND VEGETATION

Species	Relative abundance	Closed Forest	Open Forest	Wood-land	Scrub	Heath/ Sedge	River
Great Cormorant	10						x
White-faced Heron	3						x
Great Egret	1						x
Accipiter sp.*	1				x		
Grey Goshawk	6	x	x		x	x	x
Wedge-tailed Eagle	3					x	
Brown Falcon	2				x	x	
Common Sandpiper	1						
Latham's Snipe	1				x		
Brush Bronzewing	1	x					
Yellow-tailed Black Cockatoo	20	x	x	x	x	x	
Sulphur-crested Cockatoo	9	x	x	x	x	x	
Ground Parrot	4					x	
Swift Parrot	2			x			
Green Rosella	118	x	x	x	x	x	
Fan-tailed Cuckoo	12	x	x		x		
Shining-bronze Cuckoo	17	x	x	x	x		
Southern Boobook	3	x			x		
Masked Owl	2	x			x		
Spine-tailed Swift	23			x	x	x	
Azure Kingfisher	3						x
Welcome Swallow	11			x	x		x
Tree Martin	8		x		x	x	x
Black-faced Cuckoo-Shrike	7		x	x	x		
White's Thrush	16	x	x	x	x		
Superb Blue Wren	4				x		
Southern Emu-Wren	37				x	x	
Tasmanian Thornbill	184	x	x	x	x	x	
Scrub Tit	99	x	x	x	x	x	
White-browed Scrub-Wren	137	x	x	x	x	x	
Calamanthus	26				x	x	
Pink Robin	57	x	x	x	x		
Flame Robin	3	x		x		x	
Dusky Robin	5		x		x	x	
Grey Fantail	142	x	x	x	x	x	x
Golden Whistler	51	x	x	x	x	x	
Olive Whistler	128	x	x	x	x	x	
Grey Shrike-Thrush	80	x	x	x	x	x	
Striated Pardalote	17	x	x	x			
Silvereye	88	x	x	x	x	x	x
Yellow Wattle Bird	1				x		
Yellow-throated Honeyeater	97	x	x	x	x	x	
Strong-billed Honeyeater	12	x	x	x	x		
Crescent Honeyeater	292	x	x	x	x	x	
New Holland Honeyeater	6		x	x	x		
Eastern Spinebill	85	x	x	x	x		
Beautiful Firetail	4			x	x		
Black Currawong	45	x	x	x	x	x	
Forest Raven	6	x	x		x		
TOTAL		27	27	27	38	24	9

* Probably a Collared Sparrowhawk

Generally speaking, there were no great differences in species composition as one moved from closed forest through to the more open wooded areas. The only closed forest species that was not found in the more open forest is the brush bronzewing pigeon. Several species found in open forest and woodland are not found in closed forest and these include the dusky robin, blackfaced cuckoo-shrike, swift parrot, new holland honeyeater and beautiful firetail: except for the swift parrot all are probably breeding residents. Scrub differs from the forested habitats in possessing a number of species characteristic of heath/sedgeland (e.g. southern emu-wren and calamanthus) and a number of birds of prey; also present are species found nowhere else e.g. superb blue wren and Lathams snipe). The composition of the avifauna of heath sedgeland differed most from other habitats. Birds such as the southern emu-wren, calamanthus and ground parrot are virtually restricted to this vegetation type (although some make excursions to nearby habitats, specifically scrub). Birds of prey were more noticeable in this habitat then in any other probably due to the open nature of the habitat.

The Gordon River and its tributaries were poor habitats for birds (aquatic or otherwise); only nine species were seen on the transects that crossed the river, although there were reports of a further three species lower down the river at Sir John Falls Camp near Butlers Island (the black duck, black swan and white-breasted sea-eagle). Of the nine species, the silvereye was seen passing to and fro across the river from one canopy to another while the tree martin, welcome swallow and grey fantail hawked for insects over the river. The great cormorant, white-faced heron and azure kingfisher were seen on the Gordon River and its banks and the great egret was seen on the Gordon River below the Franklin Junction. The common sandpiper was seen once on a shingle bank near Transect 8 on the Gordon River.

The relative abundance of each species is also shown in Table 1 based on a score of 1 for each 50 m of a transect in which a bird was noted (regardless of the number of individuals of that species in any 50 m length). This measure will tend to underestimate flocking birds and the more common species and overestimate the larger and more vocal species. In Table 2 results are presented on an arbitrary scale of abundance as follows:

>100	very common
20-100	common
2-29	uncommon
1-2	rare

A degree of subjectivity was used in the determination of borderline cases, particularly where birds were seen on only one or two occasions and may have been transients.

From table 2 it can be seen that there are at least 18 species that are considered to be common or very common and that seven species are rare. Some birds are migratory (north-south or altitudinal) and these birds may be common in spring and early summer (e.g. cuckoos) and absent in late summer; on the other hand, altitudinal migrants (such as the flame robin) in summer but are probably more common in the winter; they may be more common at higher altitudes not included in the survey.

DISCUSSION

As a bird habitat, the area surveyed is typical of most of southwestern Tasmania (excluding coastal and disturbed regions) and the species noted were mainly those expected. It would be fair to refer to the area as depauperate in bird species compared to the drier regions of eastern Tasmania. The habitats are best described as a continuum from rainforest to heath/sedgeland with factors such as soil fertility, drainage and fire-frequency being of greatest importance. The banks of the Gordon River are extremely steep in most places and usually covered with rainforest down to the water's edge. There are few flat open banks suitable as a habitat for wading

birds and where present, the sudden changes in river depth which occur after heavy rainfall, would limit their availability and render any aquatic plant life and its associated aquatic fauna an irregular food source (at best) for water fowl.

Generally the valleys of the Olga and Hardwood are poorly drained, infertile areas with a high fire frequency, such that the dominant vegetation type is heath/sedgeland. This habitat is an unusual one, uncommon in mainland Australia. Temperate rainforest is also a habitat best developed in Tasmania and is present only as relict areas on the mainland. These two habitats are probably the most characteristic of the area but do not support the most species. Greatest species richness was found in the disturbed habitats (disturbed usually by fire), with the subsequent development of scrub or eucalypt forest. One area visited during the survey was the Truchanas Huon Pine Reserve on the Denison River, but the birds of this area did not differ from those in *Nothofagus* rainforest. There appears to be a 'spillover' of birds usually associated with closed forest into the open forest and woodland, but this apparent anomaly is a result of the use of the Specht (1970) method of vegetation structure classification. This method classifies vegetation only on the basis of the height, and density of the top layer (canopy), so that closed forests with a dense undergrowth (e.g. horiziontal scrub) would not be distinguished from a closed forest with an open understory. It is also unfortunate that Specht (1970) takes terms already in common usage (e.g. woodland and scrub), since they have certain connotations that may differ from the Specht definitions. Although southwestern Tasmania is a high rainfall area, it is ironically, also prone to wildfires. These fires, which may start in the heath/sedgelands, can spread to the closed forests. The effects of these fires may result in the eventual regrowth of 'mixed forests' (Gilbert 1959) that comprise both eucalypt and rainforest plant species, so that it is possible to have a fairly mature rainforest with an emergent story of eucalypt. The eucalypts will be of an even age and do not usually occur in the understory. A closed forest with an emergent eucalypt canopy might be classified using Specht as either open forest or woodland, depending on the density of the emergent eucalypts (Specht does mention this anomaly). It is also possible to have a growing rainforest classified as scrub due to the low height of the trees. These anomalies in classification help to explain why many birds that are usually associated with closed forests (e.g. pink robin and scrub tit), were also found in open forest, woodland and scrub. In addition Thomas (1979) has shown that the bird species in mixed forests resemble those found in wet sclerophyll rather than those in rainforest. One further problem arising from the use of the Specht classification is that a particular category of Specht e.g. closed forest, may refer to a number of distinct habitats such as *Nothofagus* rainforest or a dense tea-tree forest, two habitats that have somewhat different bird populations.

It is well known that bird species diversity is directly related to habitat diversity as measured by foliage height diversity (MacArthur *et al.* 1962). This simply means that numbers of different species and the numbers of each species are related to the complexity of vegetation at all levels in any given habitat, not just to the complexity of the uppermost layer (canopy). Therefore one would expect to find a greater diversity of birds in a closed forest with a dense understory than in one with an open understory. For this reason, it would be pointless to calculate bird species diversities for each 'habitat' as classified by Specht.

Although most of the common habitats of southwestern Tasmania were prominent in the study area, the survey was somewhat unrepresentative in that no higher altitude habitats were looked at, nor were any lakes present.

Although there are many more species in the region than previously reported (Ridpath and Moreau 1966), the overall impression is of the paucity of species in comparison with the drier eastern part of the State. It would be surprising, if one

did not obtain a bird list almost twice as long as that obtained in this survey after a similar amount of time spent in the eastern part of the State. The area may thus be described as depauperate.

Nevertheless, some birds seen during the survey are much more common in the south-western than in the drier regions of Tasmania. These birds, which include the grey goshawk, ground parrot, kingfisher, southern emu-wren, tasmanian thornbill, scrub tit, white-browed scrub wren, pink robin, olive whistler, crescent honeyeater (summer only), and Whites thrush are characteristic of the avifauna of the area surveyed, but with the exception of the ground parrot, azure kingfisher, and the southern emu-wren, all are fairly well distributed throughout the State where suitable habitat exists.

The two major habitats that characterise the area, closed forest rainforest and heath/sedgeland, are found in most of southwestern Tasmania as well as areas in the west and northwest of the State; however it may be that the areas surveyed are more isolated from the effects of man, than other similar habitats. Of considerable importance is the fact that not one exotic bird species was recorded during the survey, although there are records for adjacent areas (Fielding *et al.* 1976, Thomas 1979). This fact implies that the area is indeed a wilderness.

At least nine of the birds considered to be species endemic to Tasmania were located in the survey area. None of these birds are endangered in the State as a whole.

The status of two species should be of concern: the ground parrot and the azure kingfisher. The kingfisher is a sub-species of the mainland form. It is uncommon in Tasmania, and appears to be restricted almost entirely to the west of the State, although little information is available on its distribution. The preferred habitat of this bird is forested streams and waterways (Eastman 1970). As far as is known it is not a bird of open water and hence its status is unlikely to be enhanced by hydro-electric development.

The ground parrot is more common in western Tasmania than anywhere else in Australia; in fact it would be correct to refer to this area as its stronghold. Surprisingly, the bird was not found to be common in its usual habitat (heath/sedgeland) during the survey. This may in part be due to the facts that it is difficult to detect by the transect mode of survey (it requires 'flushing'), possesses excellent camouflage and rarely calls during the day. However, even overnight stays in sedgeland failed to detect the bird, which usually calls at dawn and dusk. It must be accepted that the bird is uncommon in the survey area, while apparently more common in areas closer to the coast. The bird is extremely rare in other parts of Australia and is considered an endangered species (Fisher *et al.* 1969).

One other bird, the orange-bellied parrot, is accepted as breeding in southwestern Tasmania and nowhere else (Milledge 1972). It is also an endangered species and one of the rarest parrots in Australia. This species was not located in the survey area. This attests to its rarity but as with the ground parrot, it may be more common near the coast. Almost nothing is known about this species in Tasmania.

The scientific significance of the results is primarily one of extending the known range of the species recorded into areas not previously reported upon. The results show that although there are many more species in the area than previously realised, the region is best described as depauperate in avifauna. The lack of exotic species, however, points to the region being a wilderness area. Importantly, the mammal survey also failed to locate exotic species of mammals with the exception of one feral cat

(Hocking *et al.* 1979).

Of ecological importance is the considerable enhancement in our knowledge of the birds inhabiting temperate rainforest (closed forest). Ridpath and Moreau (1966) considered there to be only 17 species in temperate rainforest in Tasmania, of which only 6 were common. These results show this to be a considerable underestimation. The study has also contributed to the bird atlas schemes of the Bird Observers Association of Tasmania and the Royal Australian Ornithological Union.

The survey was not an intensive one as most observations occurred in summer and much of the breeding season could not be covered due to helicopter flying restrictions at that time of year. Also, additional species (that is, species not previously recorded) were continually being seen. A number of species that could be in the area but were not seen include the water rail, brown quail, masked lapwing, little pied cormorant, hoary-headed grebe, Richards pipit, silver gull, little grassbird, orange-bellied parrot and the tawny frogmouth.

However the survey does provide valuable information on a part of Tasmania of which previously we had little scientific knowledge. Quantitative data on abundance and correlations with vegetation provide a preliminary insight into habitat preferences.

The effects of flooding part of this region may be assessed when it is realised that the habitats most under environmental pressure are the low lying valleys of heath/sedgeland and the steep banks of the river covered with temperate rainforest. These habitats are best developed in this area of the state and are poorly represented on the mainland of Australia. With its absence of exotic species of birds (and mammals), this region of Tasmania may indeed be a unique wilderness.

ACKNOWLEDGEMENT

I wish to thank the H.E.C. for its assistance in transport and accommodation during this study as well as the financial assistance it provided to one observer (Mr. R. Wilson, National Parks and Wildlife Service). I also wish to thank those members of the Bird Observers Association of Tasmania who assisted in observations (D. Thomas, L. Wall, A. Fletcher, K. Harris, M. Newman and R. Patterson), and I am grateful to the University of Tasmania for a research grant towards this project. Mr. David Thomas made numerous helpful comments on this paper.

REFERENCES

Eastman, W., 1970: THE LIFE OF THE KOOKABURRA AND OTHER KINGFISHERS. Angus and Robertson, Sydney.

Fielding, P, Newman, O.M.G. and Rose, R.W., 1976: Avian fauna of the Crotty area. *Tasm. Nat.*, 44: 1-9.

Fisher, J., Simon, N. and Vincent, J. 1969: THE RED BOOK, WILDLIFE IN DANGER. IUCN. Collins. London.

Gilbert, J.M., 1959: Forest succession in the Florentine Valley, Tasmania. *Pap. Proc. R. Soc. Tasm*, 93: 129-51.

Hocking, G.J., Guiler, E.R. and Colquhoun-Kerr, J.S., Mammal survey of the Lower Gordon River. Lower Gordon River Scientific Survey: The Hydro-Electric Commission, Hobart.

Jackson, W.D., 1965: The Vegetation . In Davies, J.L. (ed.): ATLAS OF TASMANIA. Mercury Press, Hobart.

Jarman, J. and Crowden, R., 1978: A survey of the vegetation from the lower Gordon River and its associated catchments. *Lower Gordon River Scientific Survey:* The Hydro-Electric Commission, Hobart.

MacArthur, R.H., MacArthur, J.W. and Preer, J., 1962: On bird species diversity. II. Prediction of bird censuses from habitat measurements. *Amer. Nat.*, 96: 167-174.

Milledge, D., 1972: The orange-bellied parrot in Tasmania. S.A. ORNITHOLOGIST 26: 56-58.

Ridpath, M.G. and Moreau, R.E., 1966: The birds of Tasmania. Ecology and Evolution. *Ibis*, 108: 348-93.

Rose, R.W., 1978a: Diversity and Habitat. In Gee, H.G. and Fenton, J. (eds): THE SOUTH WEST BOOK. Australian Conservation Foundation, Melbourne.

_____, 1978b: The Birds. *Lower Gordon River Scientific Survey*. The Hydro-Electric Commission, Hobart.

Specht, R.L., 1970: Vegetation. In Leeper, G.W. (ed.): THE AUSTRALIAN ENVIRONMENT, Chapt. 5.

Thomas, D.G., 1979: Tasmanian Bird Atlas. FAUNA OF TASMANIA HANDBOOK NO. 2. University of Tasmania, Hobart.

_____, and Wall, L.E., 1972: Birds of Lake Pedder and the Sentinel Range, south-west Tasmania. *Tasm. Nat.*, 29: 6-8

APPENDIX A

SPECIES CHECKLIST

Common Name	Scientific Name
Great Cormorant	*Phalacrocorax carbo*
White-faced Heron	*Ardea novaehollandiae*
Collared Sparrowhawk	*Accipter cirrhocephalus*
Grey Goshawk	*Accipter novaehollandiae*
Wedge-tailed Eagle	*Aquila audax*
Brown Falcon	*Falco berigora*
Common Sandpiper	*Tringa hypoleucos*
Brush Bronzewing	*Phaps elegans*
Swift Parrot	*Lathamus discolor*
Yellow-tailed Black Cockatoo	*Calyptorhynchus funereus*
Sulphur-crested Cockatoo	*Cacatau galerita*
Green Rosella	*Platycerus caledonicus*
Ground Parrot	*Pezoporus wallicus*
Fan-tailed Cuckoo	*Cacomatis pyrrhophanus*
Shining-bronze Cuckoo	*Chrysococcyx plagosus*
Southern Boobook	*Ninox novaeseelandiae*
Spine-tailed Swift	*Hirundapus caudacutus*
Azure Kingfisher	*Alcyone azurea*
Welcome Swallow	*Hirundo neoxena*
Tree Martin	*Petrochelidon nigricans*
Black-faced Cuckoo-Shrike	*Coracina novaehollandiae*
White's Thrush	*Zoothera dauma*
Superb Blue Wren	*Malurus cyaneus*
Southern Emu-Wren	*Stipiturus malaechurus*
Tasmanian Thornbill	*Acanthiza ewingii*
Scrub-Tit	*Acanthornis magnus*
White-browed Scrub-Wren	*Sericornis frontalis*
Calamanthus	*Sericornis fuliginosus*
Flame Robin	*Petroica phoenicea*
Pink Robin	*Petroica rodinogaster*
Dusky Robin	*Petroica vittata*
Grey Fantail	*Rhipidura fuliginosa*
Golden Whistler	*Pachycephala pectoralis*

Birds of the Lower Gordon region, Tasmania

Olive Whistler	*Pachycephala olivacea*
Grey Shrike-Thrush	*Colluricincla harmonica*
Striated Pardalote	*Pardalotus striatus*
Silvereye	*Zosterops lateralis*
Latham's Snipe	*Gallinago hardwickii*
Great Egret	*Egretta alba*
Masked Owl	*Tyto novaehollandiae*
Yellow Wattle Bird	*Anthochaera paradoxa*
Yellow-throated Honeyeater	*Meliphaga flavicollis*
Strong-billed Honeyeater	*Melithreptus validirostris*
Crescent Honeyeater	*Phylidonyris pyrrhoptera*
New Holland Honeyeater	*Phylidonyris novaehollandiae*
Eastern Spinebill	*Acanthorhychus tenuirostris*
Beautiful Firetail	*Emblema bella*
Black Currawong	*Strepera fuliginosa*
Forest Raven	*Corvus tasmanicus*

Papers and Proceedings of the Royal Society of Tasmania, Volume 114, 1980.

(ms. received 17.5.1979)

LATE MIDDLE CAMBRIAN FOSSILS FROM BEACONSFIELD, TASMANIA

by J.B. Jago
School of Applied Geology, South Australian Institute of Technology

(with one plate)

ABSTRACT

JAGO, J.B., 1980 (31 v): Late Middle Cambrian fossils from Beaconsfield, Tasmania. *Pap. Proc. R. Soc. Tasm.*, 114: 219-233 (incl. one plate). ISSN 0080-4703. School of Applied Geology, South Australian Institute of Technology, Ingle Farm, South Australia, Australia.

The only known Cambrian fauna of the Beaconsfield Trough has a late Middle Cambrian (*Ptychagnostus nathorsti* or *Lejopyge laevigata* Zone) age; it occurs 4.5 km south-west of Beaconsfield, northern Tasmania. The poorly preserved fauna includes an orthid brachiopod, plus the trilobites *Nepea* sp., cf. *Erediaspis* sp., a probable member of the Damesellidae, a possible solenopleurid, agnostoids and some fragmentary material. The fauna occurs about 140m below the contact with the overlying Tremadocian or Arenigian Cabbage Tree Formation, which suggests that most, if not all, of the Late Cambrian is not represented in the Beaconsfield area.

INTRODUCTION

The purpose of this note is to record the late Middle Cambrian fauna of the "Dally's Siltstone" near Beaconsfield, northern Tasmania. This fauna is important as it is the only Cambrian fauna known from the Beaconsfield Trough (see Williams 1978 for palaeotectonic details). Green (1959) discovered Cambrian fossils 4.5 km SW of Beaconsfield at lat. 41° 14.4'S, long. 146° 51.0'E in what he termed the Dally's Siltstone. Öpik *in* Green recorded the possible presence of *Dresbachia* and suggested a late Middle or early Late Cambrian age. Öpik (1967, p.32) recorded *Erediaspis* from this fauna and suggested a Mindyallan age. Gee and Legge (1974) reinterpreted the geology of the Beaconsfield area and suggested that the Cambrian rocks outcrop in a series of fault slices. The position of the fossil locality is shown on the Beaconsfield map sheet. The locality in question occurs in what Gee and Legge termed the Middle Arm Creek Slice. As noted in Gee and Legge (p.24) the lithology of the fossil locality is essentially a slaty siltstone with thin interbeds of sandstone. Within the fossiliferous horizons there are a few layers of quartz pebbles up to 8 mm across. These pebbles are not particularly well rounded thus suggesting a short transport history. With one exception, all the fossils are disarticulated. The fossils tend to occur concentrated in distinct layers indicating that they represent current concentrated material. The best preserved fossils occur withon one of the thicker sandstone interbeds. However, most of the specimens are very poorly preserved, particularly those found in the siltstone.

The fossils figured herein occur about 140 metres below the contact of the Cambrian rocks with the overlying Cabbage Tree Formation. Some 2 km further to the north-west, the Cabbage Tree Formation contains late Tremadocian or very early Arenigian fossils (Banks and Burrett, in press). This suggests that most, if not all, of the Late Cambrian is not represented in the Beaconsfield area. Jago (1973) has discussed details of similar "Cambro-Ordovician" contacts elsewhere in Tasmania

The known fauna is limited to a single specimen of an orthid brachiopod, plus the following trilobites which are illustrated in this note: *Nepea* sp., cf. *Erediaspis* sp., a probable member of the Damesellidae, a possible solenopleurid, two and possibly three agnostoid species plus a few fragments. The presence of *Nepea* is important because in Queensland, *Nepea* is known only from the late Middle Cambrian *Ptychagnostus nathorsti*

and *Lejopyge laevigata* Zones (Öpik 1970). The species described by Opik (1970) as *Nepea* sp. NC from the *Ptychagnostus gibbus* Zone does not belong in *Nepea*.

None of the species are preserved well enough to warrant description. Hence, only some representative photographs and brief remarks are given for each species. All catalogue numbers refer to the collection of the Geology Department, University of Tasmania.

Phylum BRACHIOPODA Dumeril, 1806
Class ARTICULATA Huxley, 1869
Order ORTHIDA Schuchert and Cooper, 1932

ORTHIDA, gen. et sp. idet
(pl.1, fig. 1)

One poorly preserved specimen of an orthid brachiopod is known from Beaconsfield.

Class TRILOBITA Walch, 1771
Order MIOMERA Jaekel, 1909

Superfamily AGNOSTACEA M'Coy, 1849
(pl.1, figs. 2-4)

Three very poorly preserved agnostoid cephala and two similarly preserved pygidia are available. The preservation is such that no generic assignments can be made. However, at least two species seem to be represented because the two figured cephala (pl.1., figs 2 & 3) appear to be different.

The cephalon figures in pl.1, fig. 2 has an angular glabellar posterior and a well rounded glabellar anterior; the cephalon figured in pl.1., fig. 3, appears to have a rounded glabellar posterior and a narrow glabellar anterior. The pygidium (pl.1, fig. 4) which occurs on the same specimen as the cephalon figured in pl.1, fig. 3, may belong to either of the cephala or to a third species.

Order PTYCHOPARIIDA Swinnerton, 1915
Family SOLENOPLEURIDAE Angelin, 1854

SOLENOPLEURIDAE, gen. et sp. indet.
(pl.1, figs 10-16)

The most common trilobite species from Beaconsfield is represented by about twelve cranidia, several free cheeks and three pygidia. It is likely that the rostrum figured inpl. I,fig. 14 belongs in this species. If the very poorly preserved complete specimen (pl.1, fig. 11) is of the same species, then there are at least twelve thoracic segments. This species appears to be affiliated with the Solenopleuridae.

Family TRICREPICEPHALIDAE Palmer, 1954
Genus EREDIASPIS Öpik, 1967

cf. *Erediaspis* sp.
(pl.1, figs 7-9)

The best preserved specimen (UT 92677) from Beaconsfield is an almost complete cranidium, which is similar to that of *Erediaspis eretes* Öpik. The major difference is the presence of a plectrum on the Beaconsfield specimen.

Family DAMESELLIDAE Kobayashi, 1935

DAMESELLIDAE, gen. et sp. indet
(pl.1, fig. 21)

The very poorly preserved spinose pydigium, UT 98241a, probably belongs in *Damesella*, *Blackwelderia*, or a related genus of the Damesellidae.

Family NEPEIDAE Whitehouse, 1939
Genus NEPEA Whitehouse, 1939

Nepea sp.
(pl. 1, figs 5-6)

Two partial cranidia (UT 50215 and UT 98235) are available. They clearly belong to *Nepea* but the preservation is such that no species assignation can be given.

TRILOBITA INCERTAE SEDIS
(pl.1, figs 17-20)

These four very poorly preserved specimens may belong in four different species, but it is possible that the thoracic segment (pl.1 fig. 18) may be of the same species as the cranidium figured as pl.1, fig. 19.

ACKNOWLEDGEMENTS

This work was supported by a grant from the Australian Research Grants Committee (E72/15101). Dr. B. Daily (University of Adelaide) helped collect the specimens. Dr. M.R. Banks and Mrs. P. Green (University of Tasmania) arranged the cataloguing of the specimens.

REFERENCES

Banks, M.R. and Burrett, C., 1980: A preliminary Ordovician biostratigraphy of Tasmania. *J. geol. Soc. Aust.*, 26: 363-375.

Gee, R.D. and Legge, P.J., 1974: Beaconsfield. *Explan. Rep. geol. Surv. Tasm.*, one mile geological map series, 8215N.

Green, D.H., 1959: Geology of the Beaconsfield district, including the Anderson's Creek Ultramafic complex. *Rec. Queen Vict. Mus. Tasm.* 10.

Jago, J.B., 1973: Paraconformable contacts between Cambrian and Junee Group sediments in Tasmania. *J. geol. Soc. Aust., 20 :* 373-377.

Öpik, A.A., 1967: The Mindyallan Fauna of north-western Queensland. *Bull. Bur. Miner. Resour. Geol. Geophys. Aust.*, 74.

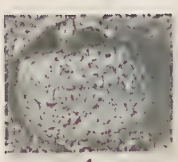
_____, 1970 : Nepeid trilobites of the Middle Cambrian of northern Australia. *Ibid.*, 113.

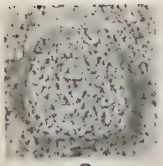
Williams, E., 1978: Tasman Fold Belt System in Tasmania. *Tectonophysics*, 48 : 159-205.

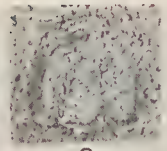
PLATE 1.

Fig. 1. Orthida, gen et sp. indet., UT 98231a, internal mould, X3.
Figs 2-4. Agnostacea
2. UT 98234, internal mould of cephalon, X5.5
3. UT 98231a, internal mould of cephalon, X8.
4. UT 98231a, internal mould of pygidium, X4.
Figs 5-6. *Nepea* sp.
5. UT 98235, internal mould of cranidium, X4.3.
6. UT 50215, external mould of cranidium, X6.
Figs 7-9 cf. *Erediaspis* sp.
7. UT 92677, external mould of cranidium, X2.9.
8,9 UT 92677, internal mould of cranidium (counterpart of fig. 7), 8, x 2.3; 9, front view, x 2.7.
Figs 10-16 Solenopleuridae, gen et sp. indet.
10. UT 98236a, internal mould of cranidium, X2.5.
11. UT 29073, internal mould of very poorly preserved, almost complete specimen, X1.5.
12. UT 98237, external mould of cranidium, X5.
13. UT 98238a, internal mould of pydidium, X4.
14. UT 98239a, internal mould of rostrum, X4.
15. UT 98233b, external mould of librigena, X2.6.
16. UT 98233a, internal mould of librigena, (counterpart of fig 15), X2.4.
Figs 17-20 Trilobita Incertae sedis
17. UT 98244, internal mould of cranidium, X4.
18. UT 29073a, internal mould of very poorly preserved thoracic segment, X1.
19. UT 98232a, internal mould of cranidium, X1.5.
20. UT 98240, internal mould of pygidium, X4.5.
Fig. 21 Damesellidae, gen. et sp. indet., UT 98241a, internal mould of pygidium, x2.

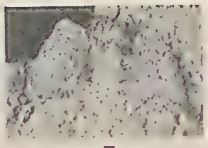
All specimens were whitened with magnesium oxide prior to photography. The brachiopod and all external moulds of trilobites are rubber casts.

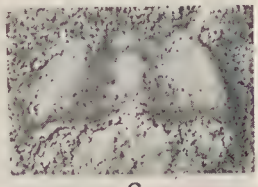

1

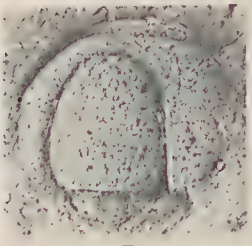

2

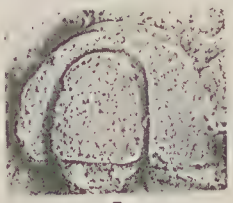

3

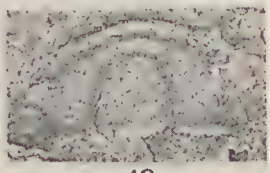
4

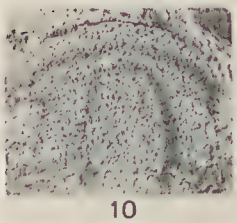

5

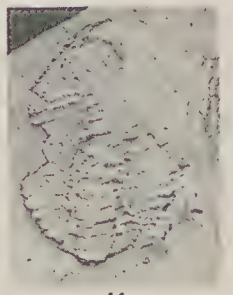

6

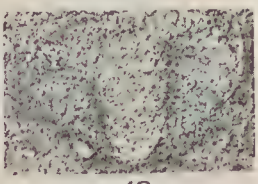

7


8


12


10

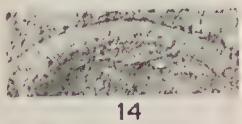

11


13

15

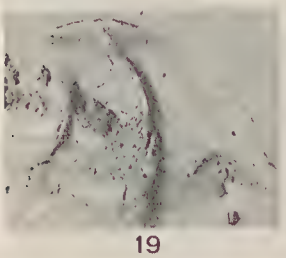
16

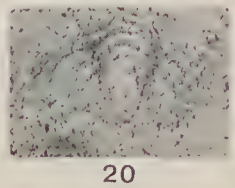
9


14

17

18


19


20

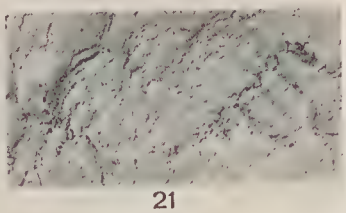

21

PLATE 1.

Papers and Proceedings of the Royal Society of Tasmania, Volume 114, 1980.

(ms. received 10.10.1979)

OYSTER COVE: ARCHAEOLOGICAL TRACES OF THE LAST TASMANIANS AND NOTES ON THE CRITERIA FOR THE AUTHENTICATION OF FLAKED GLASS ARTEFACTS

by Jim Allen and Rhys Jones
Department of Prehistory, Research School of Pacific Studies,
Australian National University, Canberra

(with one text figure)

ABSTRACT

ALLEN, J. and JONES, R., 1980 (31 v): Oyster Cove, archaeological traces of the last Tasmanians and notes on the criteria for the authentication of flaked glass artefacts. *Pap. Proc. R. Soc. Tasm.*, 114: 225-233. ISSN 0080-4703. Department of Prehistory, Australian National University, Canberra, A.C.T., Australia.

Stone, bottle glass and pottery artefacts occur at the Oyster Cove Aboriginal Station, occupied from 1847 to 1869. Criteria are advanced for recognition as artefacts of bottle glass fragments. (Editor)

INTRODUCTION

In October 1847, the Tasmanian Aboriginal Establishment at Wybalenna on Flinders Island in Bass Strait was abandoned, bringing to a close a 15 year chapter of Tasmanian history which marked the effective demise of the Tasmanians and their culture. For at least the previous 10,000 years, within the envelope of Tasmania and its near offshore islands, a human society had maintained itself in isolation. At the end of the nineteenth century the Tasmanians were once again joined to the world, an embrace across a social and cultural gap so wide that within a scant half-century, what had been a functioning society of perhaps 4,000 people was reduced to a disparate group of 35 adults and 10 children racked with disease and the ennui of the dispossessed. For the Europeans, Wybalenna was the prototype of Aboriginal reserves later to be established on the mainland, a safe place to contain a nuisance impeding colonial progress, a carpet under which to sweep a poorly understood social problem which was a by-product of colonial expansion.

A full account of the history of Wybalenna presented by Ryan (1975, 231-71) revealed predictable patterns. For its succession of European administrators, initial confidence of success in leading the Aborigines into the light of 'civilised' and Christian ways gradually foundered on a lack of government interest and dwindling financial support. For the Aborigines, transported to a country not their own, struck down by sickness, especially pulmonary diseases, poorly fed and housed, forced to labour for their keep, and taught moral precepts which clearly did not apply to many of their European keepers, any spirit of co-operation with which they might have begun the venture gradually changed to stubborn resistance. By 1847 Wybalenna was something between a cheap ration station and a gaol.

In October of that year the remnants of the Tasmanian Aborigines[1] were moved for the last time to Oyster Cove, some 40 km south of Hobart, on the mainland side of the D'Entrecasteaux Channel, and a lesser distance from where the first significant meeting between Tasmanians and Europeans had taken place some 55 years before (Labillardière 1880). (NOTE 1— A few Tasmanian Aboriginal women were of course living with sealers on various islands of Bass Strait and thus outside this Government net. They helped to found a vigorous population, the descendants of whom now number several thousands (Murray Smith 1973)). It is not our purpose here to pursue the history of Oyster Cove in any detail since this is available elsewhere (Bonwick 1870; Calder 1875; Crowther 1934, 1972; Ryan 1975). It is sufficient to relate that the patterns of Wybalenna

were repeated and that despite initial high hopes on both sides, Oyster Cove proved less satisfactory than Flinders Island. The Aborigines were housed in buildings which had previously served as a convict penal station, but which had been abandoned three years earlier because they had failed to meet convict health standards (Ryan 1975, 272). Situated for the most part on low swampy ground, the houses remained damp for most of the year and vermin flourished. Sickness increased, the gathering of traditional foods in the area diminished, rations and other government assistance decreased, and alcoholism among the Aborigines soared. By the end of 1854 the population at Oyster Cove had been reduced to 17, and by 1859 Bonwick reported that the station had become a miserable collection of huts, dirty and swarming with fleas, with broken windows and leaking roofs and all the furniture gone (1870, 276-78). By 1869 only two Aborigines, Truganini and Mary Ann Arthur, remained alive and were removed into the direct care of Superintendent Dandridge and his family. Mary Ann died two years later, and two years after that, Truganini moved to Hobart with the Dandridge family. Thus the Oyster Cove station was effectively abandoned in 1869, although some subsequent occupation of the site did take place, as Crowther relates that the superintendent's house was occupied by a local dairy farmer in the 1890s (1972, 1).

THE PRESENT DAY SITE

In the course of filming *The Last Tasmanian* (Documentary film *The Last Tasmanian*, 1978, made by Artis Films in conjunction with the Tasmanian Film Corporation, the Australian Film Commission, Cadbury of Claremont and Le Société Française de Production; directed by Tom Haydon, script written by T. Haydon and R. Jones), we were able to visit Oyster Cove in March 1977. The area remains largely undeveloped, and its present tranquility belies the suffering represented in its history. To the south of the settlement in Little Oyster Cove we inspected a shell midden and an area where outcropping silcrete had in prehistoric times been extensively exploited for implement manufacture, and the immediate surroundings revealed a dense scattering of flakes which extended well below the present low tide mark (Winter 1976).

The settlement site itself today is largely overgrown with long grass and blackberry bushes but the general area of the settlement square is identifiable from the mounds of earth and brick, presumably from fireplaces, which dot the landscape. The northern and eastern flanks of the square are particularly difficult to define for not only are these on lower and more swampy ground, but also because a sketch plan of the settlement (State Archives of Tasmania, reproduced in Crowther, 1972) indicates that there were fewer fireplaces in these areas. Here the timber buildings (Ryan 1975, 272) have left no trace above the surface. The southwestern area, being on higher, firmer ground is more discernible, and is criss-crossed by a number of dirt tracks which increase visibility.

THE COLLECTION

With the permission of the Tasmanian National Parks and Wildlife Service which administers the Act pertaining to the protection of Tasmanian Aboriginal sites, a small collection of surface artefacts was made, consisting of 34 pieces of stone, 20 pieces of bottle glass, and 12 pieces of European pottery. With the exception of three pieces of glass and two pieces of pottery which were picked up from the house mounds, all the pieces in the collection came from the cleared roadways, in the southwestern area of the site. The artefacts described here are held in the Tasmanian Museum and Art Gallery, Hobart, Tasmania, under the accession numbers: (a) M 4810/1 and M 4810/2 Bottle glass tools on fig. I/1 and fig. I/2; (b) M 4811/1 and M 4811/2 silcrete tools on fig. I/3 and fig. I/4: (c) All other finds described here - M 4812.

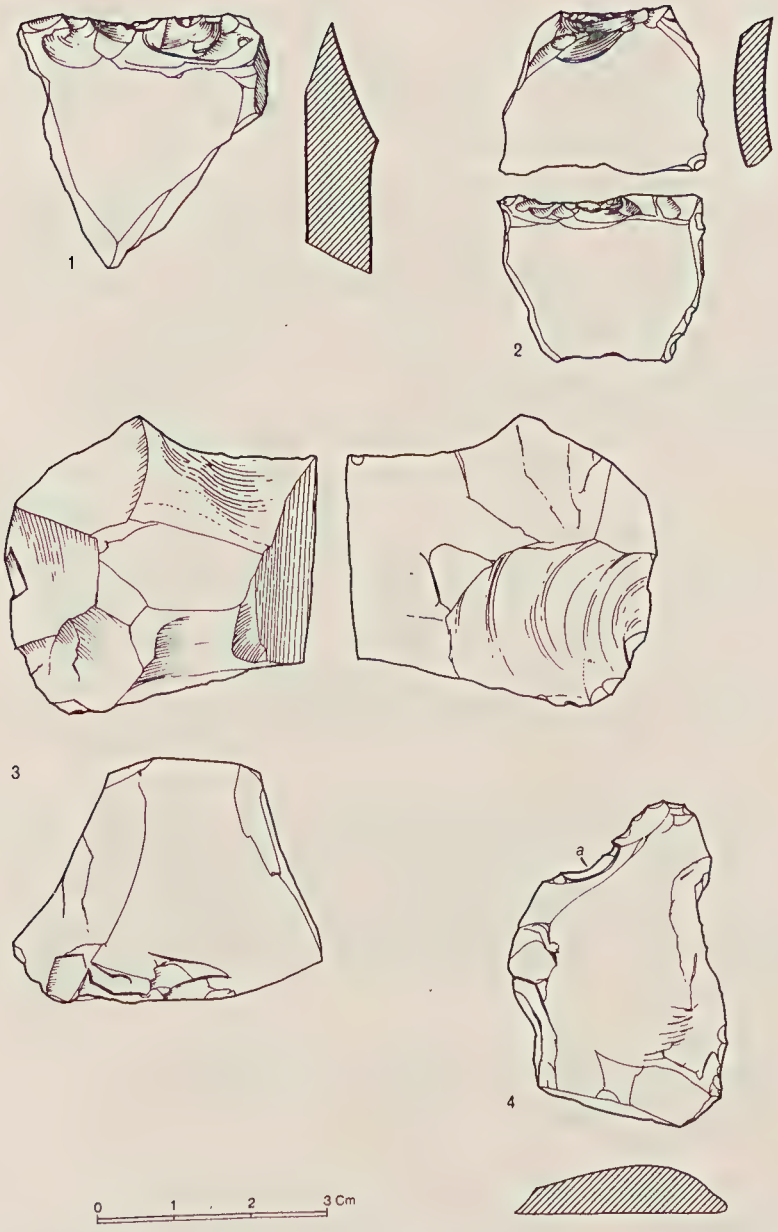


FIG. 1.- Glass tools nos. 1 and 2; and silcrete tools, nos. 3 and 4 found on the surface of the Aboriginal Settlement at Oyster Cove.

Stone

The majority of the stone pieces are small amorphous chips. Thirty-two of the pieces comprise a variety of fine grained silcretes, one piece is a fine grained chert and another is a tiny fragment of quartz (identifications kindly provided by Marjory Sullivan). The fracture patterns on the silcrete, coupled with the very small size of the pieces collected, make positive identification of 24 of the 34 pieces as Aboriginal artefacts impossible. Of the remaining ten pieces, bulbs of percussion are visible on four, and the negative flake scars on these and the remainder are consistent with their being man-made artefacts.

Two items are finished implements (M 4811). The first (fig.1:3) is a typical Tasmanian bipyramid disc core made from silcrete, with flakes taken off a zig-zag edge right around its perimeter. One side forming the steeper of the two 'pyramids' has five negative flake scars, and the other flatter 'pyramid' has two definite scars. Such cores are common in Tasmanian assemblage such as Rocky Cape North and West Point dated to within the past 2,000 years (e.g. Jones 1966, fig. 2, nos. 1,2,7 and 8). A part of the zig-zagging edge has been utilised as the base from which to work a subsequent steep edge scraper, such multiple uses being typical of Tasmanian stone tools. This steep edge has the following dimensions:

Length of edge = 25 mm; height (A) of initial flaking of the edge = 31 mm; height (B) of the subsequent step flaking = 6 mm; maximum angle = 90°; weight of the tool = 63 gm.

This compares well with the dimensions of Jones' 'steep edge scraper' (Type 2A in the typology of Rocky Cape (Jones 1971, 349-51 and table 60)). The second piece (fig. 1:4) is made on a silcrete flake with a clear bulb of percussion (length = 30 mm using the striking platform as the base line, breadth = 43 mm). Its general shape and marginal retouch suggests a flat version of a 'concave and nosed scraper' (Jones 1971, 425-26). One notch marked -a on fig. 1:4 has a lighter surface colour than the rest of the secondary flaking indicating recent damage.

Glass

The 20 pieces of glass all appear to come from liquor bottles, although only one piece is clearly recognisable - the lower wall and part of the base of a bottle blown into a metal mould (fig. 1:1). The exterior wall has the characteristic dimpled surface smooth apart from several large air bubbles. The base has a high ompholos or kick, but it is not noticeably thicker than the body wall. There is an insufficient amount of the base remaining to determine whether the piece had been knocked out of the mould using a pontil or whether the whole base was moulded, but the surface texture of the base, together with the angle of the kick would suggest the former. If this is indeed the case, that the base has not been formed in a mould but the body has, then it would be reasonable to place the manufacture of this piece somewhere before 1850 because, although moulded bases were produced before this date, in a large collection of similar bottles excavated from the Northern Territory site of Port Essington (1838-49) this form occurred in 83 out of 85 cases (the remaining two bases being moulded) (Allen 1969, 256-57).

This piece is one of eight pieces of 'black' glass in the collection, the remaining dozen pieces being a dark olive green colour. There is, therefore, no evidence in the glass collection to suggest a date later than the period of Aboriginal occupation at Oyster Cove.

Almost every piece of glass carries flake scars, produced after initial breaking, along one or more margins. The possibility that some at least of these margins have been deliberately modified by Aborigines needs to be considered and fig. 1:1 and 2 illustrates the two most convincing possibilities (M 4810). The problem is considered more fully below.

The piece in fig. 1:1 has an edge 30 mm long and 6 mm high, with a maximum edge angle of 79°. The piece in fig. 1:2 has two edges, one being 19 mm long and 5 mm high with a maximum edge angle of 77°; and the other 12 mm long, 3 mm high with a maximum edge angle of 70°.

Pottery

One of the 12 pieces of pottery (M 4812) is a fragment of a brown salt-glaze stoneware vessel, three are white earthenware pieces usually referred to as 'china' and the remainder are 'bone chine', the earthenware imitation of porcelain. Of the earthenwares four pieces are plain white, one which appears to be the lip of a cup is covered internally and externally in a light grey/blue glaze and the remaining six pieces are decorated with transfer printed floral decorations. Of these six pieces two which appear to come from the same vessel exhibit multicolour printing in five colours, three (from two vessels) are printed in green, and the last is an example of 'flowing blue'. This last piece bears on the reverse the name 'CARLTO(N)' which is presumably the design name and this cannot be identified further.

Unfortunately none of the ceramics provide any close dating evidence. The 'flowing blue' piece could date anywhere from about 1825 onwards, and one of the green transfer printed pieces from about the same time. The two multicolour printed pieces could not date before the Aboriginal occupation at Oyster Cove, and to judge from the delicacy of the design, which is in contrast to the heavy and even garish decoration of pottery found on other Australian mid-nineteenth century colonial sites, is like to be very much later.

DISCUSSION

It is clear from the foregoing description of the artefacts in the collection that a central problem is positively tying them into the period of Aboriginal occupation at Oyster Cove and on the basis of the evidence available to us the only real conclusion that we can reach at this time is that scientific excavation of the site would be the only appropriate method of isolating the separate occupations there. However it seems reasonable to attribute the stone artefacts to the Aboriginal occupation and further to consider the likelihood that some of the 'retouched' glass is a product of Aboriginal work.

Elsewhere one of us (Jones 1971, 454-72) has described at some length the stone technology of ethnographically observed Tasmanians and concluded on the basis of a radiocarbon date 0.15 m below the surface that the stone assemblage in the top levels of the North Cave at Rocky Cape is representative of the tool kit used by Tasmanians immediately prior to the time of European contact. Regional differences in recent stone tool assemblages do not appear great within Tasmania, and it is thus reassuring to find that the two recognisable tools in the present collection are types which are quantitatively well represented in the upper assemblage of the North Cave at Rocky Cape.

That stone tools were made at Oyster Cove is of interest as one facet of the continued use of traditional skills under the pressure of Europeanisation. This is no real surprise however, for Tindale has described stone tools from Kangaroo Island in South Australia which derive from two sites where four Tasmanian women were taken by sealers during the nineteenth century (1937, 29-37) and stone tools are reported also from excavations at Wybalenna (Birmingham 1976, 314). The illustrations of the Kangaroo Island implements show them again to be round and nosed scrapers (Tindale 1937, Plate III), in the terminology used to describe the Rock Cape assemblages. Although women formed the majority of the Tasmanians at Oyster Cove, some men were also present. We cannot say which sex was making or using these tools.

The presence of stone tools conforms well to the abundant evidence that at Wybalenna and Oyster Cove the Tasmanians continued to gather and hunt traditional foods. Birmingham (1976, 414-15) noted that the documentary evidence indicates that in addition to European livestock, vegetables and cereals, 'kangaroos', swans and Cape Barren geese were hunted, and that this list is supplemented by the archaeological evidence of a variety of shellfish, marsupial bones and a few mutton bird bones. Ryan (1975, 273) noted that there was during the early years at Oyster Cove an abundance of shellfish supplemented by wallaby and wombat, and a whimsical detailed drawing of the settlement by Annie Benbow, whose father had been sergeant in charge of a detail of British soldiers stationed in Oyster Cove, shows a number of traditional activities being practised. On one side, a figure identified as Truganini climbs a tree, while on the other a man clubs a marsupial (identified tentatively as a thylogale by Dr. Jeanette Hope, Department of Prehistory, ANU). In the foreground a group of women carrying traditional baskets accompany two men with guns out of the settlement. The illustration has been published by Dutton (1974, plate 63).

That the Tasmanians used bottle glass for a variety of cutting activities during the contact period is also well documented, e.g. by G.A. Robinson (Plomley 1966, 59, 61, 67, 384), James Backhouse (1843, 103) and Mrs. Hughes in Westlake (n.d.) and the uses to which glass was put have been summarised by Jones (1971, 457-59). Amongst the Tasmanian implements from Kangaroo Island, Tindale reported the finding of bottle glass 'fragments' and illustrated a retouched implement made on the base of a glass bottle (1937, 33 and plate III). He also described an implement of 'well-defined Tasmanian type' (a notched scraper) found at Kempton and fashioned on the base of a glass bottle (Tindale 1941, 1-2 and plate 1). At the time of writing, Tindale was unsure whether 'the glass is such as was used in English bottles of the early nineteenth century or whether it could be attributed to Dutch or other voyages of still earlier times', but from the clear illustrations it is possible to say that the piece is the base of a 'black' glass bottle with moulded base which could not date before the 1820s and is probably somewhat later than this. Finally, glass flakes were recovered from the excavations at Wybalenna (Birmingham 1976, 314). It would appear no accident that the implements reported by Tindale are made on the bases of bottles as the commonsense tendency to exploit the thicker parts of the bottle, usually the base, has previously been reported in different parts of the world, for example among the Aborigines who frequented the Port Essington settlement (Allen 1969, 240), among the Andaman Islanders (Man 1932, 160-61), and among the Bushmen of South Africa who purchased cheap German scent solely because the bottles were particularly suitable for flaking arrowheads from the thickened base portions (Beaumont 1961, 161).

The problem of identifying flaked glass implements

A priori it would be more surprising if Aboriginal artefacts fashioned on bottle glass did not occur at Oyster Cove than if they did, given the undisputed evidence for the use of this material in other Tasmanian contexts and the presence of bottles at the site. However it is well known that trimming, identical in every respect to the skilful modification of stone implements, may be produced fortuitously on broken glass, and in particular any curved section of bottle glass placed on a hard surface and having pressure applied against the curve will produce objects which superficially look like 'scrapers'. Such 'artefacts' can frequently be recovered from ploughed fields, cattle pastures and in particular, roadways.

To our knowledge only one serious attempt has been made to authenticate a collection of probable Aboriginal glass implements in Australia. At Port Essington in the Northern Territory the excavation of the military establishment and two nearby and contemporaneous Aboriginal middens produced over 15,000 pieces of glass of which nearly 20% were considered to be possible Aboriginal artefacts. Unlike Kimberley points made on glass (and possibly Tindale's Kempton scraper) none of these were of a form so

refined that their authenticity could not be doubted. It did not seem possible then, nor does it now, to produce a set of criteria which would positively identify any single genuine artefact from a fortuitously flaked and shaped non-artefact. However the careful analysis of that collection (Allen 1969, 213-43) did suggest some guidelines which may be summarised here.

In the large collection from Port Essington, quantitative and qualitative differences did emerge between the group suspected to have been modified by Aborigines and that which clearly had not been. For example, there was a significant difference between the amount of the wall attached to bases which were not tools and those thought to be possible tools. Also, as was stated earlier, a strong tendency towards the use of thicker parts of bottles for implements was detected by comparing the average weight of the implement group against the non-implement group, even when small struck flakes were included with the former group. The presence in the collection of a high percentage of struck flakes with bulbs of percussion also emerged as a valuable possible indicator of Aboriginal modification, as did a detailed analysis of bifacial versus internal and external unifacial flaking on the lower parts of the wall, where this was attached to a base or part of a base. Examples of glass implements stratified in the nearby middens provided a valuable comparative collection against which to judge pieces from more equivocal locations, but it also underlined a further important point, that the location of the objects coupled with commonsense still provided the best guide to validity. The environment at Port Essington, having been virtually deserted since 1849, remaining uncleared and having no roads, provides few natural agencies to explain fortuitous production.

By comparison, a large collection of glass 'implements' from Singleton in New South Wales (McCarthy and Davidson 1943, 226-27) comprising a variety of 'side, end, concave and nosed scrapers', came from a cleared field which had apparently been heavily ploughed in the past, and a further collection made there in 1967 by Davidson and one of us (Allen) produced 269 pieces of glass of which only eight could be considered as implements in terms of flaking. Both collections were made near the remains of early European buildings and were associated with European pottery and clay pipe fragments as well as Aboriginal stone implements. The latter, however, can be found eroding out of the gravel layer a few centimetres below the topsoil for some km along the banks of the Hunter River at this point, while the glass is confined to a few hundred square metres. No struck flakes were recovered at Singleton on either occasion, and if this is to be explained as being the result of manufacture elsewhere, then the implements could be expected to be distributed more widely, as are the stone tools, rather than being confined to the immediate area of European buildings - their probable origin. Finally, of the eight possible implements collected in 1967 the most convincing was the flaked base of a brown glass beer bottle, with a moulded date underneath of 1938. Thus the distribution and specialisation of the glass 'tools' coupled with what is known of the immediate environment in which they were found, combines to throw doubt on the authenticity of the entire Singleton collection.

Returning to the Oyster Cove collection, the application of such guidelines leaves us with conflicting opinions. On the positive side, the evidence that Tasmanians utilised bottle glass, and in particular that this same group of people did so at Wybalenna, lends credence to the idea that some of these pieces might be implements. As well, the illustrated piece in fig. 1:2 is flaked at opposite ends from opposite sides, a difficult configuration to achieve by accident, and both illustrated pieces are relatively thick pieces of glass. On the negative side the collection is too small to allow any quantitative analysis, it contains no struck flakes and finally the majority of the pieces come from the worst possible location on the site, the dirt roadways which cross it. The validation of these pieces as Tasmanian artefacts will ultimately depend upon the proper excavation of the site.

CONCLUSION

The value of the collection of artefacts from Oyster Cove is that it indicates that future excavations will establish the importance of the site for the archaeological documentation of the final phase of Aboriginal and European confrontation in Tasmania. As such it will join the small group of sites and collections which presently provide us with a material picture of the ethnographic or immediately precontact Tasmanians - the sites on Kangaroo Island, Wybalenna, the North Cave at Rocky Cape and the hut site being excavated by D. Ranson at Sundown Point on the west coast (Ranson personal communication). Hopefully it will contribute to the picture of technological and economic changes made in the face of an externally imposed foreign cultural dominance, and assist in an understanding of the material processes of such events elsewhere in the world, past and present.

At the same time, the scientific value of the Oyster Cove collection is at least matched by its symbolic significance. These few stone flakes and pieces of broken liquor bottles encapsulate a tragedy which in a single century had obliterated a lifestyle which, left alone, had survived the previous 400 generations. It is gratifying that the Oyster Cove site has recently received the recognition, protection and conservation it deserves as part of the Australian heritage.

REFERENCES

Allen, J., 1969: Achaeology and the History of Port Essington. *Unpublished Ph.D. thesis*, ANU, Canberra.

Backhouse, J., 1843: A NARRATIVE OF A VISIT TO THE AUSTRALIAN COLONIES. London.

Beaumont, P., 1961: The problem of glass implements. *Bull. South African Museums Association*, 7.

Birmingham, J.M., 1976: The archaeological contribution to nineteenth centry history: some Australian case studies. *World Archaeology*, 7.

Bonwick, J., 1870: THE LAST OF THE TASMANIANS. London.

Calder, J.E., 1875: SOME ACCOUNT OF THE WARS, EXTIRPATION, HABITS ETC. OF THE NATIVE TRIBES OF TASMANIA. Hobart.

Crowther, W.E.L.H., 1934: The passing of the Tasmanian Race. The Halford Oration. *Med. J. Aust.* 1(5): 147-160.

_____, 1972: The final phase of the extinct Tasmanian race 1847-1876. *Rec. Queen Vict. Mus., Launceston.* 49.

Dutton, G. 1974: WHITE ON BLACK: THE AUSTRALIAN ABORIGINE PORTRAYED IN ART. Melbourne.

Jones, R., 1966: A speculative archaeological sequence for north west Tasmania. *Rec. Queen Vict. Mus., Launceston*, 25, 12pp.

_____, 1971: Rocky Cape and the problem of the Tasmanians. *Unpublished Ph.D. thesis*, University of Sydney.

Labillardière, J.J.H. de., 1800: *Relations du Voyage à la recherche de la Pérouse....* Paris.

McCarthy, F.D. and Davidson, F.A., 1943: The eloura industry at Singleton, Hunter River, N.S.W. *Rec. Aust. Mus.*, 21.

Man, E.H., 1932: THE ANDAMAN ISLANDER. London.

Murray-Smith, S., 1973: Beyond the pale: the islander community of Bass Strait in the 19th century. *Papers and Proceedings. T.H.R.A.*, 20: 167-200.

Plomley, N.J.B., 1966: FRIENDLY MISSION, THE TASMANIAN JOURNALS AND PAPERS OF GEORGE AUGUSTUS ROBINSON, 1829-1834. Hobart.

Ryan, L. 1975: The Aborigines in Tasmania, 1800-1974 and their problems with the Europeans. *Unpublished Ph.D. thesis*, Macquarie University.

Tindale, N.B., 1937: Tasmanian Aborigines on Kangaroo Island, South Australia. *Rec. South Aust. Mus.*, 6: 29-37.

Tindale, N.B., 1941: A Tasmanian stone implement made from bottle glass. *Pap. Proc. R. Soc. Tasm.* (1941): 1-2.

Westlake, E., (undated): Tasmanian field journals of E. Westlake. *Unpublished mms.* in the Pitt Rivers Museum, Oxford. (Copy in the Australian Institute of Aboriginal Studies Library, Canberra.)

Winter, N.D., 1976: Tasmanians Aboriginal Quarries and Resources at Oyster Cove. Unpublished B.Ed. thesis, Tasmanian College of Advance Education, Hobart. (Copy in Australian Institute of Aboriginal Studies Library, Canberra).

NATIONAL MUSEUM
VICTORIA

S/533
JRNL G39